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OF THE

National Fire Protection Association

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National Fire Protection Association

INTERNATIONAL

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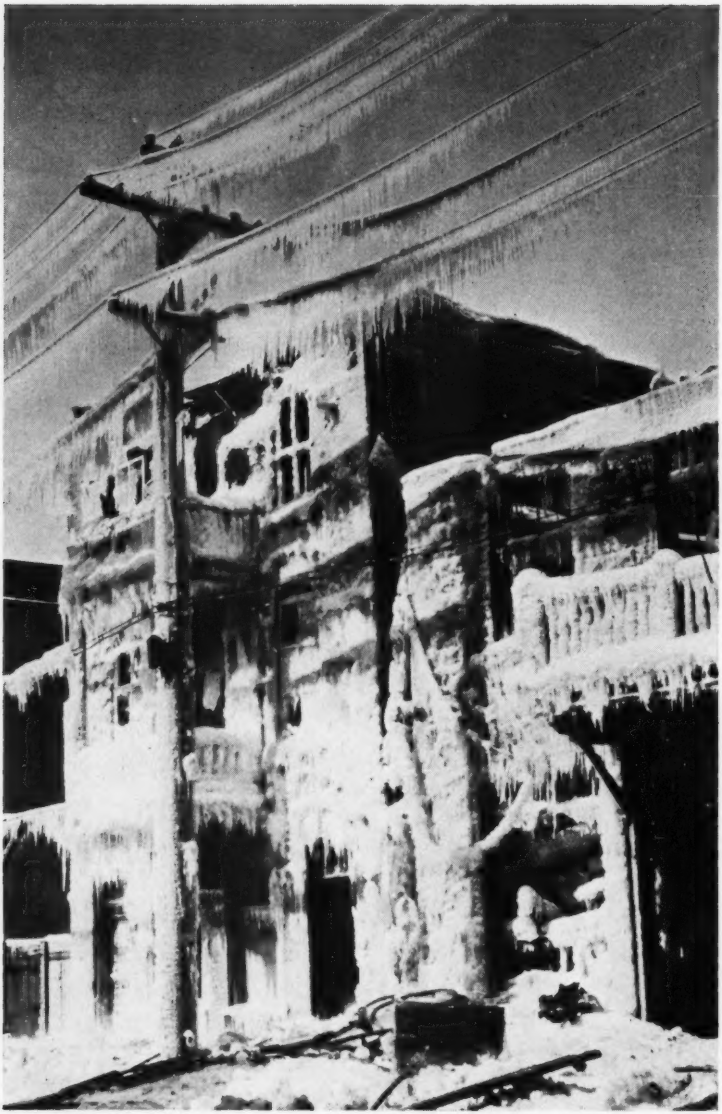

International.

Ice on the outside of a building does not stop fire within. This fire in Hull, Quebec, on March 6, 1938, occurred when the temperature was nineteen below zero, spread through a row of combustible buildings without proper fire separation, and cost three lives.

The Quarterly

Vol. 31 April, 1938 No. 4

The 1938 Annual Meeting

On May 9 another annual meeting of the Association opens in Atlantic City. Our 42nd annual session will in many respects resemble previous annual meetings in general character, but every year the subject matter of the program is new. The N.F.P.A. annual meetings are the focal point for presentation of all significant new developments in fire prevention and fire protection. The leaders in the fire protection field will be the active participants and no one who is anxious to keep abreast of the rapid progress in fire matters which comes with new industrial inventions and processes can afford to miss this annual session. The program is, however, by no means entirely technical. The popular and administrative aspects of fire prevention and fire protection are likewise always covered in N.F.P.A. meeting programs, which bring to the members the latest and best thought on the psychological and public relations aspects of the subject, as well as the technical features.

* * * * * *

The Committee Reports

The technical regulations which give guidance to the public on the best methods for prevention and control of fires developed by our forty committees are a very important part of the work of the N.F.P.A. Every year new reports are submitted or amendments are made in existing standards to keep them up to date. The N.F.P.A. procedure in developing these reports is designed to make the final result an expression of the opinion of the entire Association. Everyone interested has an opportunity to express his views and secure consideration of his suggestions. In the interest of efficiency the committees themselves are limited to a relatively small group of men who have special technical qualifications in their respective fields. Only about five hundred out of a total Association membership of four thousand serve on the committees. Every other member of the Association, however, may have something to contribute and no one should hesitate to express his opinions on the reports, either by letter or on the floor of the annual meeting. The reports are all printed and circulated in advance of the meeting, both to the N.F.P.A. membership and to any other interested individuals and organizations who ask for them. This procedure is designed to bring out all angles of opinion on the various subjects and to make the reports as adopted represent the very best thought of all concerned.

While the reports are technical, they are largely designed for use by non-technical men, and it is the general aim of the committees to prepare texts which can be read and used effectively by any individual of ordinary intelligence. Any items in these reports which are not clear to the non-technical reader should be clarified, and accordingly no member of the Association should hesitate to comment on a report merely because he may feel that he knows less about the subject than the members who are serving on the committee which drafted it. Every member of the Association thus has a responsibility for the committee reports. It is to be hoped that at the 1938 annual meeting, as in other meetings past and to come, each member of the Association will secure and review any reports in which he is particularly interested, and feel free to express his opinions thereon so that the regulations, when finally adopted, may represent the consensus of opinion of the entire Association and be in such form that they may be effectively used, not only by the technical experts, but by the general public.

* * * * * *

"Fireproof" Firetraps

The public has been lulled into a belief that a "fireproof" building affords safety from fire, though the fire protection fraternity fully realizes that a fire-resistive structure, unless designed with due regard to the possibility of the start and spread of fire in combustible contents and interior trim, may be likened to a giant stove in which the occupants may be roasted. The tragic fire in the Hotel Plaza in Jersey City, described in this QUARTERLY, shows what may happen in a building of modern "fireproof" construction. Only the fortunate accident of the start of the fire in mid-morning instead of after midnight prevented much heavier casualties. The construction of the Hotel Plaza was several generations ahead of that of the school in St. Hyacinthe, Quebec, where fifty-one lives were lost on a bitter night last January, but the relative number of casualties in the two fires apparently reflect the difference in the population of the building, the time of day, and the number of fire department ladders available to a much greater extent than the difference in construction.

The Hotel Plaza fire shows that the minimum legal requirements of building codes cannot be expected to achieve their purpose with any degree of certainty unless supplemented by a proper understanding of the fundamentals of fire safety in the operation and maintenance of buildings. In this case, presumably in full compliance with the law, an ample number of stairways had been provided and enclosed in fire-resistive walls. But, like thousands of other stairways in "fireproof" buildings, they opened directly into the lobby, with no doors. Fire doors were provided at the stair shaft openings to upper floors, but at the time of the fire the doors on one stair shaft were fastened open, with fastenings presumably provided by the management for the purpose. Fire inspectors find similar conditions in almost every city.

Hotels, office buildings and similar occupancies are often treated leniently in fire safety requirements on the theory that they contain no concentration of highly combustible material and that the fire hazard is slight. This is a convenient theory, but experience shows that most buildings of low hazard occupancy do have highly combustible contents at one time or another. And when such combustible contents are ignited under the right combination of circumstances, the stage is set for a disaster. In the Hotel Plaza lobby a Christmas tree furnished the tinder. Exhibit booths, flammable decorations, a 5-gallon can of varnish spilled by a careless painter, the excelsior wrappings from new furniture, a case of samples of pyroxylin articles, or various other casual or temporary hazards might be responsible for a similar fire.

A fire in a ventilator shaft of the Hotel New Yorker in New York at 4 A.M. on March 6 provides another illustration of the possibility of fire in the modern "fireproof" building. In this case the location of the fire was such that the guests were merely inconvenienced by smoke, and automatic sprinklers stopped the spread of the fire to basement rooms where combustible materials were stored. This fire, however, is another reminder that fires can and do occur even in the best modern buildings.

Fires such as these, and the fire hazards inherent in air conditioning and other new developments resulting from inventions yet to be made, show the fire protection fraternity that the enactment of laws on building construction, important though this is, does not of itself assure fire safety, and that we have a never ending responsibility in public education in fire prevention and in guiding new developments along safe lines.

* * * * * *

Sprinklers and Sprinklers

On July 29, 1937, the S.S. *City of Baltimore* burned soon after she had left Baltimore for Norfolk, Va., with the loss of three lives and injuries to a number of passengers who were forced to jump overboard, and almost total loss of the vessel. In the account of this fire, which was published in the October, 1937, QUARTERLY (page 133), reference was made to statements of members of the crew that the fire fighting equipment of the vessel included a sprinkler system which was said to have been in operation, but without apparent effect on the fire.

An official report on the sinking of the vessel has now been released by the U. S. Department of Commerce, recording the details of investigation made by a special board of inquiry. This investigation brings out the fact that the sprinkler system was merely an equipment of perforated pipes in the cargo spaces arranged for manual control. While called a sprinkler system, and installed under old requirements for sprinklers to protect such areas on passenger vessels of combustible construction, the equipment apparently resembled the embryonic sprinkler systems installed in textile mills a hundred years ago, and bore little relation in actual efficiency to the modern automatic

sprinkler system which has a record of 96% successful performance in modern practice. It appears that not only was the system limited by the feature of manual control and questionable distribution of water on the seat of the fire, but it was supplied by a fire pump of limited capacity—a capacity which might have been sufficient to extinguish a fire satisfactorily with a standard automatic system arranged in accordance with present practice, but totally ineffective under the circumstances, particularly in view of the fact that a considerable number of manual hose stations were likewise operated. In addition to the deficiency in the fire protection equipment brought out by this report, it appears that there were various other features of construction, equipment and operation on this vessel which fell seriously short of the standards for safety to life and property from fire developed by the N.F.P.A. Marine Section and which are largely reflected in current requirements applied by the U. S. Government. It is also of interest to note in connection with this particular fire that a contract had already been arranged for installation of a modern sprinkler equipment. It appears likely that if this modern installation had been completed the story of this fire would have been entirely different.

Even modern sprinkler installations on shipboard, like similar installations on shore, are effective only when the water supply is maintained. On March 20, 1938, the sprinklered *City of Buffalo,* laid up for the winter at Cleveland, was practically destroyed by fire with a loss estimated at $368,000. The sprinkler system was without water. The connection which might otherwise have been used by the fire department had been disconnected while the ship was undergoing repairs according to one report, or according to another report, was broken by the heat of the fire. This fire has no bearing on the ability of sprinklers to fulfill their function of protecting life while the vessel is in commission, but does serve as a reminder that when water is shut off a ship sprinkler system the results are likely to be just as serious as when water is shut off a system protecting a building.

* * * * * *

Court Decisions on Truck Transportation

The Kansas Supreme Court has reversed its decision upholding the ordinance of the City of Ottawa, which prohibited the transportation of gasoline through the city streets in trucks containing more than 600 gallons. The reverse decision was based on the new Chapter 283 of the state laws creating uniform traffic regulations. This chapter restricts the power of cities to regulate traffic within their corporate limits. The original decision was published in abstract form in the July, 1937, QUARTERLY, page 32.

Justice Smith, in delivering the opinion of the court, showed that the new chapter of the state law expressly repeals a statute giving the cities power to regulate and control the use and speed of automobiles and motor vehicles within their corporate limits, although it leaves the cities with power to regu-

late the kind, size of tread, weight, and direction of travel of vehicles which may use any particular street, alley or other public property, and to prescribe routes by which vehicles of a weight of more than 5000 lbs. with or without load shall move through streets in the city. The court held that the above changes to the then existing laws removed the police power necessary to enact the ordinance in question.

The new chapter says in Section 7:

> The provisions of this act shall be applicable and uniform throughout this state and in all political subdivisions and municipalities therein, and no local authority shall enact or enforce any rule or regulation in conflict with the provisions of this act unless expressly authorized herein. Local authorities may, however, adopt additional traffic regulations which are not in conflict with the provisions of this act.

It goes on to describe in detail safety measures for both city and country traffic, and enumerates various things which the chapter will not be construed to prevent cities from doing within the reasonable exercise of police power. The power to enact the Ottawa ordinance is not included. As regards the transportation of dangerous articles, the Commissioner of Motor Vehicles is authorized to promulgate regulations which he shall deem advisable for the protection of the public. Dimension and load limits of vehicles are prescribed. These would permit the transportation of many more than 600 gallons of gasoline in trucks. The court held that the provision of a maximum load implies that trucks might transport that heavy load. The chapter provides for exceeding the prescribed load and dimensions in special cases, but the court held that the legislature did not intend local authorities to have power to enact an ordinance providing for a lighter load than is provided for in the statute.

The Ottawa ordinance forbidding the transportation of gasoline in larger amounts than 600 gallons is far different from one designating upon what streets trucks loaded with gasoline might move through the city. According to the court, the practical effect of a holding that the ordinance in this case is valid would be to render meaningless the provisions of the state statute stating that local authorities shall have the power to direct the operation of trucks and other commercial vehicles on designated streets and highways.

Another recent decision of fire protection interest is that of the U. S. Supreme Court which upheld the South Carolina truck law. This law limits the size and weight of trucks, and was attacked on the ground of interference with interstate commerce. The Supreme Court, in a decision rendered February 14, 1938, indicated that South Carolina, in enacting a reasonable law to control the use of her highways, had done nothing to conflict with Federal regulation of interstate commerce. This decision has only an indirect bearing on fire-safety, but is of interest as indicating the authority of States, within their borders, to control the fire hazard features of interstate truck transportation in the interest of public safety.

The St. Hyacinthe, Quebec, School where forty-one boys and five priests lost their lives in a fire that started with an explosion of coal gas at 2 a.m. The building was of wooden interior construction, was without automatic sprinkler or automatic alarm system, and had inadequate exits.

St. Hyacinthe School Fire, Quebec.

Forty-one boys and five priests lost their lives on January 18, 1938, when fire destroyed the Sacred Heart College at St. Hyacinthe, Quebec, a small manufacturing city about 30 miles from Montreal. The fire followed an explosion, attributed to coal gas, at about 2 A.M., and almost instantly the 37-year-old brick-joisted building was enveloped in flames. The building was valued at $500,000 and insured for $254,000.

The available information on the details of the fire and on the pertinent features of construction and arrangement of the building is meagre. The N.F.P.A. Department of Fire Record endeavored, through fourteen different inquiries to various local authorities and other possible sources of information, to secure a full account of this holocaust which might be valuable in showing the relative importance of the several factors, and in pointing the way towards the best methods of avoiding similar disasters in the future. There was an official investigation, but the N.F.P.A. request for a report was answered by the Deputy Attorney General of Quebec as follows: "We are sorry we cannot grant your request, as reports of this nature are private and confidential, and for the sole information of this department."

Interior Construction.

The circumstances of the fire would indicate that the building was entirely of wooden interior construction with open stairs, no interior cut-offs and no firestopping, that heating was by an old hot air system not installed with modern safeguards, and that such fire escapes as were installed were wholly inadequate as to location and arrangement. There is, however, no positive information available on these features. Unfortunately, the information received was limited to the incomplete data summarized in the following account.

It is definitely reported that the building was four stories high, although the photographs indicate that one section was only two stories in height, and that at least a part of what was reported as the fourth floor was a finished attic space with dormer windows. The third and fourth floors were dormitories, where 96 boys of ages between 11 and 18 years and a few priests were sleeping. On the ground floor were sleeping 26 priests and 5 employees. Outside iron fire escapes were provided on two sides of the building. Also provided were standpipes and hose, a manual fire alarm system, and two dozen portable fire extinguishers. The condition of this equipment at the time of the fire is not known, but apparently none of it was a factor in the fire. The St. Hyacinthe fire department consists of 11 regular firemen and 12 volunteers. Policemen also respond to alarms and assist in fire fighting operations.

The watchman, an old man with one arm, said he failed to discover anything unusual when he made his 1 A.M. round. The occupants, awakened by an explosion about 2 A.M., were confronted by stifling smoke and flames coming from the ventilators into the dormitories. Almost instantly the exits were cut off by flames, and the outside iron fire escapes were cut off by flames coming from the windows. A few of the occupants escaped by crawling through the smoke to a metal chute fire escape. (No data as to exact type or location.) Others rolled themselves in their bedclothing and jumped from upper windows into snowdrifts. None of the occupants had opportunity to dress, and those who did escape suffered severely from the 8 below zero temperature before they could find shelter.

The top floor dormitory housed 43 of the smaller boys. Priests directed these boys down an outside fire escape to the roof of another section of the building. From this point the boys were urged to jump into the snowdrifts below, but most of them, too frightened to jump, remained on the roof until it collapsed a short time later. Most of the persons on the ground floor escaped.

The first alarm was telephoned to the fire department by a passer-by at 2:03 A.M., and fire apparatus arrived within three minutes. By this time the building was already enveloped in flames and the department devoted its efforts to raising ladders to the windows. Several boys and priests had jumped to the ground. Priests assisted in rescue work, which was necessarily limited by the men and ladders available. A great many ladders would have been needed to do all the required rescue work. A lack of life nets is probably responsible for the loss of most of the boys trapped at windows and on the roof.

Attempts of firemen to enter the building were blocked by bolted doors, as the building was customarily locked early each evening. So complete was the destruction of life and property that only eight of the 46 victims could be identified when removed from the ruins.

The cause of the fire has not officially been determined, but a coal gas explosion is thought to have been responsible. The heating and electrical equipments were inspected a few months before the fire and pronounced safe. Electric lights were burning when the fire was discovered, so electricity is not regarded as a probable cause. However, at the time of the disaster the five furnaces in the building were being pushed because of the extreme cold. Records compiled by the Dominion Fire Prevention Association show that almost three-fourths of all school fires in Canada during the past 16 years have been due to heating equipment.

Regardless of the immediate cause of this fire, no expert judgment should be required to label as a firetrap a building of combustible interior construction which housed 100 persons on upper floors without automatic sprinklers, automatic fire alarm or adequate exit facilities. A coroner's jury, after a 13-day inquiry into the disaster, attached criminal responsibility for the fire

to no one, but recommended that dormitories in other old colleges and schools be placed on the lower floors instead of on the top floors, and that rigid inspection of such buildings be made to remove fire hazards. The jury also recommended installation in non fire-resistive buildings of an automatic fire alarm system with connections to fire headquarters.

As an aftermath of this tragedy there has been a wave of interest in improving the fire protection facilities of all schools in Canada. The attorney general of Ontario has ordered the provincial fire marshal to inspect all private residential schools in that province, and while this work is being done the fire marshal sent out to all the principals of these schools a circular, drawing to their attention the hazards from fire and the necessity of having their buildings properly constructed, with particular attention to exits, fire escapes, and sufficient and prompt means of giving alarms.

J. Grove Smith, Dominion Fire Commissioner, has issued a bulletin pointing out that within six months every institution in Canada could be made substantially fire safe. Mr. Smith also points out that out of 4200 school fires in Canada since 1922, the eight largest disasters alone accounted for 342 fatalities, and that 90 per cent of the loss of life in all institutional building fires has resulted from flammable structural conditions.

Fire Protection in Engineering.

By Robert S. Moulton, Technical Secretary,
National Fire Protection Association.

Fire protection is now a recognized branch of engineering, with a large body of engineers specializing in various phases of fire protection and a well-developed literature of its own, including engineering handbooks and numerous publications. Fire protection, while a specialized subject, necessarily impinges upon almost every other field of engineering. The specialist in fire protection may have to deal with a wide variety of problems involving almost all of the various recognized branches of engineering. The fire protection engineer, while often specializing in some one phase of the subject, recognizes that he cannot expect himself to acquire complete knowledge of all the other branches of engineering with which his work may bring him in contact and makes a practice of consulting with engineers in other fields when he encounters highly specialized problems in electrical, civil, mechanical, chemical, mining or other branches of engineering.

The engineer in other fields likewise is concerned with fire protection problems. Practically every branch of engineering in its major and minor subdivisions has to deal with matters bearing on prevention of fire or its extinguishment. All too often the engineers in other fields do not recognize the fact

that fire protection is a specialized branch of engineering and often fail to inform themselves on special fire protection features pertaining to their special problems, or to consult with fire protection engineers whose broad experience may be valuable. We frequently hear of cases where engineers concerned with some special manufacturing process have found that there was some special fire hazard in the operation of the process and have endeavored to develop their own safeguards without taking advantage of the advice of fire protection engineers or the experience in protection of special hazards in other industries. The result is often the development of some equipment or fire protection method of which the engineer is proud, feeling that it is an original development, whereas the equipment actually developed is similar to some embryonic type of automatic sprinkler or fire alarm equipment that in other fields of fire protection was replaced by more effective devices forty or fifty years previously.

The engineer in any field dealing with his special problems is all too apt to overlook fire safety, thinking of it perhaps as an incidental and relatively minor factor with which he need not concern himself. The results often seem most tragic to the fire protection engineer, where, because of lack of forethought and application of specialized fire protection knowledge, some process or structure is completed without proper regard to fire safety. If the engineer or architect had given thought to fire protection in the original design, what when completed presents a severe fire hazard might have been made fully safe at little or no additional expense. When the building is completed or the process in operation, it is often too late to make changes without prohibitive delay and expense, and operations continue until there is a disastrous fire or explosion which, in addition to the money loss, may cripple the business by interruption of production and consequent loss of business to competitors. Even if there is no fire the owner pays an annual penalty in increased fire insurance rates.

Frequently the engineer or architect has to deal with state and municipal officials who are enforcing legal requirements on fire safety. The engineer who does not have a fundamental background of fire protection engineering is often at a great handicap in such cases as he is not in a position to talk with the city or state officials on the basis of specialized engineering knowledge. The man, however, who has a background of the fundamentals of fire protection engineering has an understanding of the purposes of the laws and ordinances, and is often able to so adjust his plans that the intent of the law is met in a manner acceptable to the enforcing officials without unnecessary expense or inconvenience which might be involved in literal compliance with some arbitrary interpretation.

Every engineer in every branch of the profession should know something about fire protection, not only the features involved in his own specialized

branch of the engineering profession, but in the broad aspects of the subject which may affect his work directly or indirectly in a great variety of ways. He should realize that fire protection engineering is a specialized profession and if, because of necessary preoccupation in his own specialized work, he is unable himself to acquire the necessary technical fire protection knowledge, he should be ready to consult the specialists in this field whenever technical questions of fire protection arise, or rather he should go a step farther and take pains to assure himself that there is not some fire protection aspect which he may have altogether overlooked in the design of his project. Some knowledge of fire protection should thus be a part of general engineering knowledge for every well-trained engineer. It is generally agreed that the technical or engineering school graduate, to fill his proper place in society and to be most successful in his job, should have a background of general knowledge, as well as the highly specialized knowledge of the specific subdivision of engineering for which he is trained. Fire protection is one such field of general knowledge which can readily be acquired by the engineer, and such knowledge may in many situations put the engineer in a position to render unusual service in his community or in the business organization with which he is connected.

There is no better way to keep in touch with the modern developments in fire protection engineering than through the literature of the National Fire Protection Association, which should be available for reference in every engineering library and should be part of the reading matter in every engineering curriculum which bears any direct or indirect relation to fire protection. In this way the engineer or the student of engineering may obtain the needed background to form the basis of his judgments as to when special attention to fire protection is required. Just as engineering curricula commonly devote some attention to business law not to make the engineer a lawyer, but to give him a groundwork of the fundamentals so that he may decide intelligently when he needs legal assistance, just so some knowledge of fire protection should be in the background of every engineer so that in the projects for which he is responsible he may avoid unnecessary hazards to life and property from fire.

Meeting of Board of Directors.

Atlantic City, January 15, 1938.

Present.

Albert T. Bell, Chairman	Eugene Arms	F. T. Moses
George W. Elliott, President	H. T. Cartlidge	S. L. Nicholson
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There were also present Percy Bugbee, Assistant Managing Director, Robert S. Moulton, Technical Secretary, and Horatio Bond, Chief Engineer.

Business Transacted.

1. Verbal reports were rendered by the Executive Office on Membership, Publications, Advertising in Publications, Field Service Activities and Volunteer Firemen's Section, and the Managing Director was requested to express to the Chairman of the Membership Committee the appreciation of the Board of his devoted and energetic service.

2. Co-operation with and participation in the activities of the American Standards Association were discussed and Member A. R. Small was nominated to succeed himself as N.F.P.A. representative on the Board of Directors, A.S.A., for the three years beginning January 1, 1938.

3. The proposed technical membership division of the Association was laid upon the table as inexpedient to advance at the present time.

4. It was voted to receive the report of the special Committee on Electrical Committee Membership, that the committee be discharged, and that the Board be recorded as follows in respect of the make-up of the Electrical Committee:

(*a*) That the present representation of the International Association of Electrical Inspectors in the make-up of the Electrical Committee is ample.

(*b*) That although the National Municipal Signal Association as reorganized has changed its status as defined by its objects, it still has representation in the Electrical Committee.

(*c*) That the application of the International Association of Governmental Labor Officials for a representative in the Electrical Committee be granted.

(*d*) That with the foregoing the Board considers that the governmental and public interests are amply represented upon the Electrical Committee and that the representation of other groups is consistent with the respective interest.

5. The Executive Office memorandum prepared at request of the Advisory Committee on a proposed *Research Committee* was considered and the Chairman of the Board authorized to appoint a special committee to study the subjects contained in the memorandum and report thereon to the Board.

Committee Affairs.

6. The Electrical Committee was authorized to change the dates of its meetings.

7. The revised report on Suggestions for Fire Protection of Lacquer Manufacturing Plants (Proceedings, 1937, page 351) was referred to the Committee on Manufacturing Hazards for further consideration.

8. An editorial change in the 1937 report of the Committee on Salvaging Operations was approved as follows:

Revise third paragraph under the caption "Warehousing and Storage," Proceedings, 1937, page 516, to read:

"To facilitate the spreading of covers, piles of merchandise should not exceed sixteen feet in height nor a width of twenty feet. Three feet clearance should be allowed between the top of piles and trusses, girders, or other structural members. Where piles are high, means should be provided to make them stable, such as staggering boxes or bags and pyramiding by steps, so that a man can climb to the top to spread covers. Aisles of at least two feet should be left between piles and sides of building, fire walls or fire stops."

9. The report of the Committee on Technical Committee Procedure was accepted, and the following action taken in accordance with the recommendation of the committee:

The committee appointments approved by the committee in accordance with the authorization of the Board at its last meeting were confirmed as printed in the 1937 Year Book.

The creation of a Committee on Municipal Fire Apparatus was confirmed.

The action of the committee in approving Tentative Interim Revision No. 22 for inclusion in the 1937 edition of the National Electrical Code, and approving No. 23 but not for inclusion in the 1937 edition, was approved.

The Electrical Committee was instructed to desist from independently developing requirements on motion picture film for inclusion in the National Electrical Code and to confine any provisions on film in the Code to text referring to or quoted from the Regulations on Nitrocellulose Motion Picture Film.

The previous ruling was confirmed to the effect that spray nozzle systems of protection are essentially special protection for special hazards and as such belong within the jurisdiction of the Committee on Manufacturing Hazards and are not to be considered as sprinkler systems, even though they have various points in common with the ordinary sprinkler system.

The following scope statement for the Electrical Committee was adopted:

The preparation and revision of the National Electrical Code and the study, consideration and report on electrical hazards to life and property, except as special uses of electricity beyond the scope of the Code are covered by other committees.

10. The following committee appointments were confirmed:

Blower Systems.

Arthur L. Faubel, Cork Institute of America.

Winthrop M. Jones, replacing C. B. Langdon, Factory Insurance Association.

Building Construction.

Robert F. Beresford, American Institute of Architects.

Electrical.

O. K. Coleman, serving as representative of Edison Electric Institute.
F. V. Magalhaes, American Institute of Electrical Engineers, replacing H. S. Warren.
Samuel R. Todd, replacing A. G. Hall, International Association of Electrical Inspectors.
David Grimes, replacing Leslie F. Curtis, Radio Manufacturers Association, Limited Membership.

Fire Prevention and Clean-up Campaign.

F. X. Ahern, Deputy Fire Commissioner, Province of Quebec.

Fire Pumps.

Winthrop M. Jones, replacing C. B. Langdon, Factory Insurance Association.

Municipal Fire Apparatus.

Joseph N. Sullivan, Chairman, Commissioner of Public Safety and Chief, Utica, N. Y., Fire Department.
F. X. Ahern, Deputy Fire Commissioner, Province of Quebec.
Paul V. Betters, U. S. Conference of Mayors.
A. O. Boniface, Motor Fire Apparatus Manufacturers' Association.
George W. Booth, National Board of Fire Underwriters.
Loren S. Bush, Board of Fire Underwriters of the Pacific.
S. O. Cook, Motor Fire Apparatus Manufacturers' Association.
Russell Forbes, Commissioner of Purchase, City of New York.
Clarence Goldsmith, National Board of Fire Underwriters.
J. J. McElligott, Fire Commissioner and Chief, New York Fire Department.
R. E. Mottesheard, Chief, Dearborn, Michigan, Fire Department.
Milton I. Parker, Missouri Inspection Bureau.
Samuel J. Pope, Chief, Boston Fire Department.
J. Ray Roe, Chief, Abilene, Texas, Fire Department.
C. R. Welborn, Underwriters' Laboratories, Inc.

Protection of Records.

John H. Derby, Member at Large, replacing John C. Knight.
Hugh M. Flick, replacing Herbert O. Brigham, Supervisor of Public Records, State of New York.

Public Water Supplies for Private Fire Protection.

E. H. Kent, replacing Earl Moore, Railway Fire Protection Association.

Safety to Life.

W. E. Cathcart, replacing Robert Scott, Railway Fire Protection Association.

Tanks.

Winthrop M. Jones, replacing C. B. Langdon, Factory Insurance Association.

Truck Transportation.

W. Dent Smith, Delaware Safety Council.

11. A communication on the hazards of paper book matches was considered without action.

12. It was voted to request the Committee on Articles of Association to give consideration to Article No. 7 governing the Nominating Committee in the light of the discussion by the Board.

Fourth of July Injuries, 1937.

Journal of the American Medical Association.

From 1903 to 1916 the American Medical Association presented annual summaries of injuries resulting from the celebration of the Fourth of July. Since 1916, which was the first year without a single case of tetanus, these reports have been discontinued. Unfortunately in recent years a considerable increase in the number of injuries has occurred; it seems expedient therefore to renew the annual reviews.

Deaths.

This year there were twenty deaths reported as due to the celebration of the Fourth of July with fireworks or firearms. The distribution by states is given in Table 1. Burns from fireworks resulted in the death of seven youngsters, gunshots were responsible for the death of four boys, two men were drowned after their boat had been wrecked by an exploding firecracker, a toy cannon explosion killed a man, and a fire caused by explosion of a display of fireworks in a store caused the death of six women and girls.

The worst single accident of the year occurred in Nampa, Idaho, on July 1. (Reported in October, 1937, QUARTERLY, page 110.) A shelf of fireworks in a drug store caught fire and exploded, with thirty people in close proximity. This tragic display resulted in the death of six and the serious injury of several others. Another strange accident occurred, according to newspaper reports, on Cayuga Lake, N. Y. According to the story told to authorities, three men started celebrating by shooting cherry bombs and firecrackers along the shore of the lake, finally pushing out into the lake in a rowboat. A large firecracker exploded under the boat, tearing a hole in it, and two of the three men were drowned.

Tetanus.

Only two cases of tetanus were reported this year, one in Minnesota and one in Ohio. Both patients recovered. The small number is due, however, not so much to lack of opportunity for tetanus to occur as to the splendid co-operation of physicians, police, hospitals and first aid units in giving tetanus antitoxin immediately following an injury. Evidently all are thoroughly cognizant of the necessity for giving tetanus antitoxin even in the presence of what appear to be relatively slight injuries.

Table 2 lists the number of injuries by type and cause. The total number of injuries recorded for this Fourth of July celebration numbered 7205. Obviously this figure errs on the side of underestimation. Thus, although 4292 questionnaires were sent out to hospitals requesting them to list the Fourth of July injuries treated, only 2463 were returned. In addition, doubtless more

Table 1. Deaths by States.

State	Number of Deaths	State	Number of Deaths
California	1	New York	3
Florida	1	Ohio	1
Idaho	6	Rhode Island	1
Maryland	1	Texas	1
Massachusetts	2	Utah	2
New Jersey	1		

injuries were treated in first aid stations or by physicians in their offices than were treated in hospitals. The total number of injuries, therefore, was probably far in excess of those which were actually recorded.

Comparative figures with other years since 1916 are not available and hence any attempted contrast at this time would be futile. Attention, however, should be drawn to the fact that in 1916, the last year of the previous annual reports, there was not a single case of tetanus reported.

Study of the table in the light of available information discloses several important points. New Jersey, which only this year received the benefit of a state law against fireworks, had only seventy-two injuries, while Pennsylvania with only 2.4 times the population (1930 census) and without such a state law had 991 injuries. In fact, many of the individual reports from New Jersey indicated the "bootlegging" of fireworks across the state line from Pennsylvania, and so the latter state may well be considered to have contributed materially to those injuries from fireworks which actually occurred in New Jersey. Many individual hospital questionnaires from New Jersey stated voluntarily that this year for the first time their hospitals treated no injuries from fireworks, in contrast to previous records of from 100 to 150.

Michigan, which also possesses a state law against fireworks, had only 190 injuries, while Illinois, without such a state law and a population approximately 1.5 times as large, had 485 injuries.

The Southern states, as a group, reported few injuries from fireworks. This is due principally, as was mentioned on numerous questionnaires, to the fact that in most regions of the South there is no fireworks celebration of the Fourth of July. Fireworks, however, are used at Christmas time, and many of the hospitals reported that serious injuries frequently occur at that time. (An example is that of Dec. 24, 1936, at Asheville, N. C., where a preview of the Nampa, Idaho, tragedy occurred. A fireworks display in a downtown store exploded, killing several people and burning others.)

In spite of the fact that several of the principal cities of the country have ordinances against the sale of fireworks inside their corporate limits, most of them had a large number of injuries. Table 3 lists the injuries for several of them and their rates per hundred thousand. Again it is obvious that local regulations are only slightly effective in preventing such injuries, since the forbidden fireworks can easily be purchased outside the city limits and brought in by automobile.

Table 2. Types and Causes of Injuries.

State	Type of Injury					Cause of Injury		
	Burns and Lacerations	Loss of Eye	Injury to Eye	Loss of Finger, Hand, or Other Member	Total Injuries	Crackers and Torpedoes	Display Fireworks*	Cannon and Firearms
Alabama	7	..	..	..	7	6	..	1
Arizona	29	1	2	..	32	30	1	..
Arkansas	6	..	1	..	7	7	..	..
California	458	..	20	7	485	468	14	3
Colorado	114	1	3	1	119	117	1	1
Connecticut	101	..	3	..	104	93	..	11
Delaware	23	..	2	..	25	23	1	1
Dist. of Columbia	73	..	5	..	78	76	2	..
Florida	21	..	2	..	23	21	..	2
Georgia	9	..	..	..	9	6	3	..
Idaho	51	1	..	..	52	48	3	1
Illinois	465	1	18	1	485	445	27	13
Indiana	263	..	14	1	278	211	50	17
Iowa	67	..	6	3	76	71	2	3
Kansas	90	..	3	..	93	91	1	1
Kentucky	58	1	2	..	61	50	..	10
Louisiana	12	..	..	..	12	12	..	..
Maine	64	..	2	1	67	62	2	3
Maryland	114	..	9	..	123	113	7	3
Massachusetts	351	..	23	2	376	357	4	15
Michigan	184	..	6	..	190	188	2	..
Minnesota	77	..	12	..	89	80	7	2
Mississippi	..	..	..	..	..	..	..	..
Missouri	497	1	10	2	510	475	3	32
Montana	39	1	10	..	50	48	1	1
Nebraska	44	..	5	..	49	44	5	..
Nevada	..	..	..	..	..	..	..	..
New Hampshire	34	..	3	3	40	38	2	..
New Jersey	70	..	2	..	72	70	1	1
New Mexico	..	1	..	..	1	1	..	..
New York	1,322	1	46	2	1,371	1,302	52	17
North Carolina	2	1	..	1	4	1	2	..
North Dakota	11	1	2	..	14	14	..	..
Ohio	330	1	20	2	353	320	18	15
Oklahoma	90	2	8	1	101	91	6	4
Oregon	42	..	..	3	45	45	..	..
Pennsylvania	955	1	30	5	991	948	24	19
Rhode Island	372	..	9	..	381	379	2	..
South Carolina	..	..	..	..	..	..	..	..
South Dakota	9	..	..	..	9	9	..	..
Tennessee	1	..	..	..	1	..	..	1
Texas	32	..	1	..	33	28	3	2
Utah	27	..	2	2	31	26	3	2
Vermont	18	..	2	..	20	19	1	..
Virginia	18	..	..	..	18	18	..	..
Washington	147	1	5	..	153	138	14	1
West Virginia	27	..	1	..	28	24	3	1
Wisconsin	88	..	4	..	92	90	1	1
Wyoming	9	..	1	..	10	7	2	1
Unknown	37	..	..	..	37	36	1	..
Totals	6,858	16	294	37	7,205	6,746	271	185

*Includes sparklers, rockets and roman candles.

Serious Injuries.

In addition to the deaths and cases of tetanus, newspaper clippings and hospital questionnaires recorded a considerable number of persons, mostly children, so seriously injured that they will bear the scars of their experience for the rest of their days. There were many bad burns, chiefly from sparklers, in many instances requiring prolonged and persistent hospital care and often resulting in permanent scarring. In one serious accident in Jamaica, N. Y., according to newspaper clippings, three high school students were seriously injured by experimenting with certain chemicals for celebration purposes. Both hands of one boy were amputated and one hand of another. The eye injuries, from the standpoint of numbers and permanent disability, were perhaps the most appalling. Table 2 lists them by state, but can give no true picture of their individual significance.

Table 3. Injuries in Principal Cities

City	Injuries	Rate per 100,000
New York	524	7.56
Chicago	225	6.66
Philadelphia	201	10.30
Detroit	62	3.95
Los Angeles	45	3.63
Cleveland	64	7.11
St. Louis	322	39.17
Baltimore	56	6.95

In spite of the apparent effectiveness of the campaign by the American Medical Association which terminated twenty-one years ago, there has been an evident increase in the misdirected celebration of Independence Day by dangerous fireworks. This increase has occurred in spite of the fact that municipalities and good citizens generally have continued their efforts to regulate the sale and use of fireworks. Part of the increase may be due to lack of social consciousness of this dangerous activity. Part seems to be due to the fact that in spite of legal regulations the almost universal use of the automobile has made city limits and even state lines no longer any material barrier to the transportation of much illegal material. All of the previous reports of "The Journal" on this subject stated that "the responsibility clearly rests with city governments." Evidently this no longer holds strictly true, since city governments cannot enforce regulations outside their limits, and transportation is now too easy.

Liquefied Petroleum Gas Systems.

N.F.P.A. Committee on Gases.

In recent years members of fire departments and fire prevention bureaus have shown concern over the hazards of liquefied petroleum gases. The highly flammable nature of these gases has given rise to great misgivings in some cases. These fears have largely resulted from observations made of improper methods of storage and handling employed during the infancy of the liquefied gas industry by irresponsible operators. If the nature of the gases is not understood these fears naturally become even greater.

The N.F.P.A. Committee on Gases has kept in close touch with the rapid development in the use of liquefied petroleum gases, has in its preliminary reports anticipated progress in the industry, and has had an important influence in directing the entire development along safe lines. This committee activity, in accordance with the general policies of the N.F.P.A., has been based upon the belief that these products, like any other flammable materials having an inherent fire and explosion hazard, may be used with safety if reasonable precautions are observed. The committee has developed not only standards which give detailed good practice requirements,* but has also put these in legal form so that they may be adopted by state and municipal authorities.† These requirements are already in legal effect in at least two states.

It is important to realize that petroleum gases have, in their natural state, similar fire hazard characteristics to illuminating and other gaseous fuels, whether manufactured or natural. If properly handled they can be used with safety, but, in certain mixtures with air, they will explode if ignited. Petroleum gases, being a natural product not found everywhere and not ordinarily subject to economical distribution by pipe lines, are shipped in mobile containers. For this purpose they are compressed and liquefied. When the pressure is relieved most of the liquids return to their gaseous state and are so used, but the lower vapor pressure liquids usually require indirect heating to insure complete vaporization. They are, therefore, shipped and stored in liquid form, although burned as a gas. In transit and storage they are called liquefied petroleum gases.

*Regulations for the Design, Installation and Construction of Containers and Pertinent Equipment for the Storage and Handling of Liquefied Petroleum Gases; Regulations for the Installation of Compressed Gas Systems other than Acetylene for Lighting and Heating; Regulations for the Design, Construction and Operation of Automobile Tank Trucks and Tank Trailers for the Transportation of Liquefied Petroleum Gases.

†Code for the Construction and Installation of Liquefied Petroleum Gas Systems recommended for enforcement by fire marshals or other regulatory authorities.

Properties.

The principal liquefied petroleum gases used are commercial and industrial grades of propane and butane, and sometimes mixtures of the two. These products are obtained from two principal sources: from natural gas and from refinery gases formed in the refining of petroleum. The gases are shipped in specially designed tank cars under their own vapor pressures, which vary with their temperatures. The vapor pressures, at 70° and 100° F., of typical commercial propane and commercial butane are shown in the following table.

Vapor Pressure Lbs./Sq. In. Gauge	Commercial Propane	Commercial Butane
at 70° F.	124	31
at 100° F.	195	65

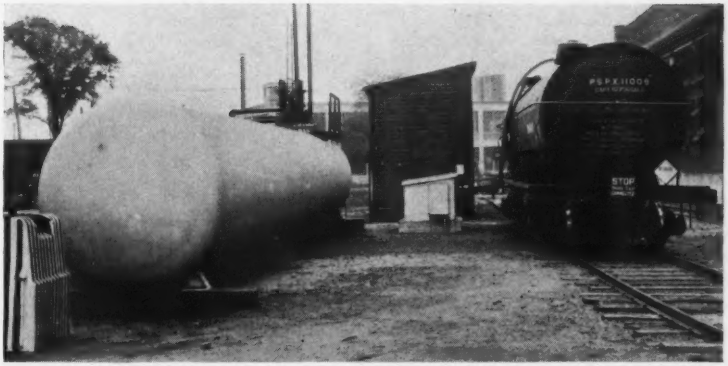
The National Fire Protection Association, through the Committee on Gases, has prepared and issued rules or specifications for liquefied petroleum gas containers other than I.C.C. cylinders of drums or tanks for tank cars. These rules or specifications are based on the Unfired Pressure Vessel Code of the A.S.M.E., but it was necessary to specify design pressure based on the vapor pressures of liquefied petroleum gases at various temperatures.

The principal difference between the liquefied petroleum gases and other gaseous fuels, so far as their handling is concerned, is the fact that the former have specific gravities greater than air, while the gravities of most of the other gases are less than air. Liquefied petroleum gases will, therefore, if allowed to escape, tend to collect in low places or depressions, where, if ignited before dissipation, they may cause a severe explosion. Ventilation of such places is therefore important.

In their natural state the liquefied petroleum gases have the general odor of gasoline and gasoline products, and are not readily discernible. In order to provide for the ready detection of gas leaks in gas-air mixtures well below the lower explosive limit, a suitable odorant is added to most of the liquefied petroleum gases now marketed.

Tank Car Handling.

The first handling with which we are concerned is in car movements, since no attempt will be made here to discuss hazards involved in production plants, tank farms, pipe line or marine terminals. Tank cars for liquefied petroleum gas are of special design, and the Interstate Commerce Commission regulations provide the specifications for their construction. These rules do not allow any bottom connections to the tank, thus eliminating possible bottom valve leakage. The gas is handled through connections in a manhole cover at the top which is not removable except for repairs, inspections, and the like. This arrangement controls the escape of vapors. The filling and discharge lines of these cars must be equipped with automatic excess flow valves, so as to shut off the flow of the product in case of a break in the unloading



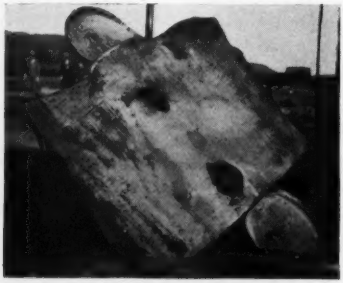
A tank car being unloaded through fixed connections to a large petroleum gas storage tank. Note the warning signs on the rear of the car.

connection. In a similar way, back flow from the storage system is avoided by use of suitable automatic check valve in the unloading line. Generally, a high pressure hose connection is used in the line from the tank car to storage. If the car is accidentally moved, the hose acts as a weak link and prevents tearing out the line or valves. When a hose breaks there is momentary full flow from car and storage; then the automatic valves shut off the flow from both sources.

Each tank car is equipped with a safety relief valve. Most cars have a type of valve which, in addition to the metal to metal seat, has a resilient composition seat on the discharge, making it possible to have a vapor-proof closure at all times even though the inner seat might leak. This resilient seat material may be replaced while pressure is on the valve. The valves are removed and retested every five years.

Since the advent of the liquefied petroleum gas industry, there have been a number of tank cars in wrecks and it is interesting to note the fact that in all cases of which the N.F.P.A. has record the car tank shell has withstood the shocks of wrecks; and unless fire were present from some other source there has not been a loss of car contents. In one wreck a liquefied petroleum gas car was in the midst of a fire created by gasoline tank cars which had ruptured. The fire burned out the lead gasket on the liquefied petroleum gas car manhole cover, thus allowing the liquefied petroleum gas to escape and burn. In such a case the fire generally should not be put out, but allowed to burn itself out. Extinguishing the flame would allow the vapors to escape into the atmosphere, with possible ignition from some source and with resultant damage. In another tank car wreck the underframe and trucks were sheared off and the tank rolled over and over without damage to tank shell or to valves protected in the dome housing. The tank was placed on a flat car and

A typical two-cylinder domestic system. Another type of two-cylinder system uses no cabinet, but protects the valve mechanism with hood or covers over the cylinders.



The twisted remains of a sub-standard liquefied petroleum gas domestic storage tank that exploded during the group fire at Malibu Beach, California, on December 15, 1930. Modern tanks are equipped with relief valves and other safety devices to prevent such explosions.

sent on to its destination, where the liquefied petroleum gas was unloaded in the normal way.

Unloading Tank Cars.

In planning a possible unloading location for liquefied petroleum gas, the matter of distance requirements immediately comes to mind. Naturally, the safest location is one remote from other operations. From a practical standpoint, however, distance is not the all important item when picking a location; the mechanical design of the tank car, unloading pipe lines and storage are much more important. The system should be carefully installed so that it will be a closed leak-proof job, and will minimize the possibility of any gases escaping and traveling to a point of ignition. Preferably, the unloading site should be on a dead end siding not used for any other purpose, in order to decrease the possibility of the car being accidentally moved or bumped while unloading. A "Stop" sign or derail device should always be in place while unloading, as a warning to train crews.

Some tank cars are equipped with steam coils between the insulation and the bottom of the tank car shell. The purpose of these coils is to enable heating of the liquid in extremely cold weather so as to create sufficient vapor pressure to force it out through the eduction lines. Care should be exercised not to heat the car's contents to a point where the resulting vapor pressure would release through the safety valves.

In unloading, liquefied petroleum gas is forced from the cars by pressure differential, or pumping. The pressure differential method is generally used on butane. If the natural vapor pressure in the tank car is above that in the storage tank, this pressure unloads the car. At times, before the car is entirely

unloaded, the pressure will equalize and flow to storage will stop. Air pressure or gas pressure is then placed on the car, or the liquid is heated in order to obtain the required pressure differential.

Both piston and rotary pumps are used for unloading. Special care must be used to insure close clearance. If electric power is used in the same building or compartment as the pump, the motor and electrical equipment must be suitable for hazardous locations as prescribed by the National Electrical Code. Standard squirrel cage motors are suitable if installed in a separate building or if separated from the pumps by a vapor-proof fire wall. This same precaution should be used for location of internal combustion engines which drive pumps. No open flames should be allowed in or around the pump house.

Domestic Installations.

The first large scale use of liquefied petroleum gases, particularly propane, was as fuel for domestic and commercial cooking, water heating, and refrigeration. This field of application until 1933 accounted for the largest part of the total liquefied petroleum gas consumption, but since that time has been exceeded by industrial use. In domestic systems, propane is generally used because it is self-vaporizing at all temperature conditions encountered. Butane and butane-propane mixtures are being used to some extent, but with these products a vaporizer is often necessary. Propane and propane-butane mixtures in domestic applications are usually stored and transported in cylinders of 60 to 300 lbs. fuel capacity, built in accordance with Interstate Commerce Commission specifications.

Domestic service is at the present time being generally furnished in one of four general types of installations:

(1) A two-cylinder system in which two cylinders of gas (usually containing 100 lbs. each) are located outside of the house on a firm foundation. The cylinders are connected through flexible connections to a pressure regulator which reduces the pressure of the gas to approximately 0.4 lb. per sq. in. before it enters the house line. By means of individual line valves and the valves on each cylinder, gas can be withdrawn from either one or both of the cylinders. Customary practice is to use from one cylinder until it is empty, then turn on the other cylinder and turn off and disconnect the empty one. The empty cylinder is returned to the supplier and a full one ordered to replace it.

(2) A one-cylinder system in which one cylinder, usually holding from 100 lbs. to 420 lbs. of propane, is directly connected to a gas pressure regulator and thence through a flexible tubing to the permanent gas piping entering the house. Instead of replenishing gas supply by changing cylinders as in the two-cylinder system, the cylinder is refilled at periodic intervals by pumping propane from a tank truck. Gauging of contents of the cylinder is done by weighing or metering. The flexible hose connection permits the cylinder to be

A service truck filling a one-cylinder domestic system. On the side of the truck is the pump which supplies the necessary pressure. Valves are located in a protecting rim of heavy steel.

raised from its base enough to be weighed. In some of the larger cylinders used in this type of installation gauging is done by liquid volume by means of magnetic or dip tube gauges.

(3) A system generally of two cylinders or two drums using butane or propane-butane mixtures in which the fuel is withdrawn through a dip tube from the bottom of the cylinder in liquid form. The liquid enters the house line and is vaporized either in a special vaporizer or in the stove burner itself by means of preheater sections.

(4) Systems which employ storage containers, other than I.C.C. cylinders or drums, permanently located on the premises, whether above or below ground. The fuel is sometimes drawn from these containers in the gas phase and passed through a regulator, where the pressure is reduced before entrance to the building. In some of these systems the fuel is drawn from the container in the liquid phase and passed through a liquid regulator, where it is vaporized or partially vaporized before entering the building. After entering the building this fuel is further vaporized through a special vaporizer, which may or may not require artificial heat. The gas is then led to a low pressure regulator before entering the lines to the appliances.

All of the above systems have many things in common so far as safety requirements are concerned. Systems in which only gas goes to the appliance are rated by Underwriters' Laboratories as less hazardous than systems where vaporizing is done at the appliance.

Location of Cylinders.

It is of primary importance that cylinders containing liquefied petroleum gas, except when used for welding and cutting and other special industrial applications, be located outside of buildings other than those specially provided for the purpose. This applies to extra cylinders in storage as well as to cylinders connected to the gas line. For utmost safety all cylinders should be kept outdoors at all times, or in a fire-resistive building especially constructed

for the sole purpose of cylinder storage, and posted with suitable warning signs. When liquefied petroleum gases are used from cylinders for welding and cutting operations the special N.F.P.A. rules should be followed.

Cylinders of gas connected to the house line are usually set upon a substantial foundation or otherwise securely mounted to prevent breakage of the line in case of ground settling. If not possible to use such a foundation, the effect of settling can be somewhat guarded against by using flexible connections, such as copper tubing or one of the special types of propane hose which have been developed. When small cylinders are used and properly equipped they may be attached to the sides of buildings.

For protection against tampering and exposure to the weather, the cylinder valve, manifold and regulator assembly of the gas system are protected by a ventilated metal or fire-resistive covering which can be locked in place. In some systems this covering is over the above mechanism only, while in other systems a metal cabinet is used which completely encloses the cylinders as well.

Safeguards in Charging Cylinders.

The changing or charging of cylinders is preferably done by daylight, entirely away from open fires and permitting no artificial light, other than incandescent vapor-proof lights, within 10 feet of the cylinders. It is also necessary to keep electrical apparatus having hot filaments or which may cause sparking away from the vicinity of the cylinders and regulating valves.

In propane systems it is customary practice to reduce the pressure of the gas from cylinder pressure down to approximately 0.4 lb. per sq. in. in one stage, the pressure regulator being located outside of the building, either directly connected to the cylinder of gas or mounted in a cabinet immediately adjacent to the cylinder. This method of installation insures that the vent from the regulator, in case of diaphragm rupture or other accident, will be to the outside air. In some systems pressure regulation is in two stages, with the low pressure regulator located in the house. In any case the initial regulator must be outside the house, whether of high or low pressure type. In some of the liquid systems where a vaporizer is used, it and a pressure regulator are sometimes located in the house. In either of these cases it is necessary to vent the space above the diaphragm of the inside located regulator to the outside air by means of connecting pipe or tubing. The discharge of such vents, as well as the discharge from safety relief devices on the system, must be located not less than five feet away from any opening in the building which is below the level of the discharge. Liquefied petroleum gases, being heavier than air, tend to settle to the ground and, unless given an opportunity to dissipate into the air, may enter a ground level opening which is too close to the discharge point.

The low pressure line in every gas system is provided with a pressure relief device of some type. Where the low pressure regulator is located outside

A large scale application of petroleum gas on this typical commercial kitchen installation; the gas enters the range through the pipe on the right, and the straight line continuation of the pipe distributes it to the various burner and oven attachments.

the building, the relief valve is also located outside, either as an integral part of the regulator or independently connected to the low pressure line. Where the low pressure regulator is located inside the house, the low pressure relief device is usually also located indoors, but is vented to the outside in the same manner as the regulator. The two general types of relief devices in use are spring-loaded safety valves, and mercury seal devices. Their purpose is, of course, to prevent build-up of excessive line pressure in case of failure of the regulator to function properly. Where gas enters a house at a pressure in excess of the low pressure regulator setting, then this line must be equipped with a safety relief valve.

Cylinder valves, as well as all other valves in the high pressure portion of the system, are of the diaphragm type or provided with special packing designed to prevent leakage of gas around the valve stem, thus preventing leakage of gas around the valve stem. On cylinders which are disconnected and replaced when emptied, only one valve is ordinarily used. In systems where the cylinder is filled while in use, two valves or a dual valve are used. The standard valves used usually have a special left-hand female thread so that

the only connections which can be made to them are those furnished for the purpose.

Each cylinder containing liquefied petroleum gas is equipped with one or more safety devices approved, as to type and location, by the Bureau of Explosives and intended to prevent explosion of the normally charged cylinder when it is placed in a fire. These safety devices for liquefied petroleum gas cylinders are either of the fusible metal type or spring-loaded relief type. Frangible disc type safety devices are not recommended for these relatively low pressure gases.

Most gas systems are equipped with a shut-off valve for the use of the consumer in shutting off the gas in case he leaves the premises or wishes to disconnect appliances.

Piping in systems conveying only gas to the building and appliances is standard full-weight wrought iron or steel, or brass or copper pipe, or approved seamless copper, brass, or other approved non-ferrous tubing. It is tested and proven free from leaks at a pressure not less than one and one-half times the maximum working pressure to which it is to be subjected. In some systems of the type in which liquid enters the building only heavy-walled seamless brass or copper tubing is used.

Underground Domestic Type Installations.

On the systems utilizing underground tanks, some different safety problems occur.

In many territories the soil is corrosive and electrolysis occurs in varying degrees. This fact may not be known to the marketer installing the tank, and for proper protection all tanks installed underground require additional metal thickness and a proper coating of protective material. Care must be taken in applying this coating to cover the tank completely. Some types of coatings are susceptible to injury during handling and require protection such as is provided by burlap or similar wrapping.

Tanks may sometimes be installed where high ground water levels occasionally occur, and in such cases, to prevent flotation, tanks must be weighted or secured to a foundation.

The National Fire Protection Association rules require all non-I.C.C. containers to be built to the specifications of the American Society of Mechanical Engineers for unfired pressure vessels. They likewise specifically provide for the additional thickness of metal that must be added to the walls and ends of the cylinders to protect against dangerous corrosion.

As with the cylinder type installations, the gas is taken from the underground containers of some systems in the gaseous state and from others in the liquid state. The same general methods of installation of regulators and other equipment apply to underground systems. A proper manhole with cover,

Tarver Photo.

In the Crowley, La., butane explosion and fire of Oct. 22, 1936, the truck and tank involved were of flagrantly sub-standard design. When the discharge pipe snapped as the tank was being removed from its cradle on the truck there was no excess flow valve to stem the escape of the gas. Good practice requires a specially designed truck and tank equipped with safety devices that are designed to prevent this type of accident. (This fire was reported in the January, 1937, Quarterly.)

arranged to prevent tampering, is necessary to protect the valves, regulator, gauging device, relief valve and other equipment on the container.

Industrial Applications.

In the industrial and gas manufacturing applications of liquefied petroleum gases, shipment is usually made by tank cars, from which the fuel is transferred to a storage tank located at some point on the premises being served. The storage tank and its accessories are the most important part of such a liquefied petroleum gas system. Care in its design, fabrication, installation and maintenance is important from a safety viewpoint. As a flammable product under pressure is being handled, storage must be designed to eliminate possibility of rupture and leaks. The use of the specifications of the American Society of Mechanical Engineers should be strictly adhered to. Liquefied petroleum gas is not a corrosive material, therefore inside corrosion is not a factor. The outside of aboveground tanks should be given the best of maintenance and kept finished with a light-reflecting color.

The use of proper fittings and accessories on the storage tanks is of utmost importance. In all cases where pipe connections are made to the tank they should have shut-off valves installed as close to the tank as practical, and automatic excess flow valves installed on the inside of the tank. The purpose of such excess flow valves is to prevent flow of tank contents into outside atmosphere in case of breakage of any line. Care should be used to see that the excess flow valve used is satisfactory for the particular size of line used and for the desired gas or liquid flow. All valves and accessories should be protected against mechanical damage and tampering.

Safety Valves.

Safety valves are necessary equipment to relieve excess pressure which might be caused by overfilling of tank, causing it on increased temperature to become hydrostatic (liquid full), or by above-normal temperatures. In the latter case the increased temperature would generally be caused by exposure to fire. All bulk storage tanks should have a safety valve outlet riser extending ten feet above the tank and discharging vertically upward without return bends or other obstructions that might deflect the gases back onto the tank. If other than upward opening discharges were allowed and the gases became ignited, the flames might impinge on the tank, causing an increase in temperature of the liquid within, thus causing a greater discharge of gas. Another reason for discharging the relieved gases upward is to eliminate possible hot spots from flame impingement, which might cause local overheating of the metal and possible failure at that point.

If a tank is exposed to a fire a hose stream should be directed over its surface to keep it cooled, thus preventing an increase in gas pressure which

A modern liquefied petroleum gas tank truck unloading into a storage container at an industrial plant. Note the light-reflecting color of the tank and the high vertical relief valve pipes.

would operate the safety relief valves. In case the safety valves relieve in the presence of a fire, the gas discharging from pipe riser should immediately be ignited. Unburned gases traveling to the fire and there being lighted may result in a serious explosion.

No shut-off valve should be installed between the safety valve and the tank unless the arrangement is of a design whereby two or more safety valves are so installed that at least one of them will always have a free flow. As an example, a three-way valve is at times used where the inlet to valve is always open and one or the other of the outlets are always open. As one outlet is closed the other opens. With this arrangement and a safety relief valve on each outlet connection, each with sufficient relieving capacity, the tank is properly protected from excess pressure.

Industrial Uses.

In industrial plants and gas manufacturing plants both propane and butane are used. In the industrial plants the gas is used for many applications. The uses include annealing, normalizing, carburizing, air heaters, forging, laboratory burners, cloth singeing and calendering, bakery ovens, as a furnace atmosphere, and many other varied uses. In some cases it is used as a solvent, refrigerant, or chemical raw material. In these instances special safety provisions must be made after a study of the particular application.

Although butane at the advent of the industry was used almost wholly in industrial plants and gas plants, propane today is being used in approximately 85% of all new installations. Commercial butane (boiling point 12° F. to 30° F.) must be taken from the tank as a liquid and passed through a hot water or steam-heated vaporizer to convert it to gas. Vaporizers in industrial plants should be installed in a special building provided expressly for that purpose and should be separated from main buildings by a vapor-proof, noncombustible wall. The hot water heater or steam boiler should never be installed in the vaporizer building. A safety relief valve should be installed on all vaporizers.

There is a possibility that the necessary heat to insure vaporization cannot be secured from the air and the liquid from the vaporizer may overflow into the plant lines. This is guarded against by a float-actuated shut-off valve or other suitable means.

Industrial propane (initial boiling point minus 50° F.) vaporizes naturally under normal temperatures without the use of a vaporizer unless the quantity used is so large that the necessary heat to insure vaporization cannot be obtained from the air, in which case additional heat must be supplied. Propane is usually used as a gas directly from the storage tank. When vapor is taken from the storage tank to plant, a pressure reducing valve should be installed at the tank. This pressure reduction will eliminate condensation in outside lines under certain temperature differentials between pipe line and storage.

In many gas plants and at times in industrial plants the gas is premixed or diluted with air before distribution. Where the mixture is a total premix (a combustible mixture) special precautions should be taken. In such cases approved flame arrestors should be used.

This very general discussion of the characteristics of liquefied petroleum gas, types of equipment, and the precautions that should be used to insure safe handling and use, should be supplemented by a study of the available literature on these important subjects. In all cases the rules of the National Fire Protection Association should be used in designing and installing gas systems.

Careful attention on the part of liquefied petroleum gas producers and distributors, and regulatory bodies, to the promulgation and observance of proper safe practices, has permitted rapid expansion of the liquefied petroleum gas industry with a good safety record. The industry is at present expanding at an even greater rate than in previous years with the application of these gases to new processes. Continued rigid observance of safe practices and prompt promulgation of necessary regulations when the need arises will insure an even better safety record for the future.

An Experiment on Water Curtains.

Performed by Underwriters' Laboratories, Inc.,
(Member N.F.P.A.)

It is common knowledge that water is a very poor conductor of heat. Its thermal capacity, which is by definition the amount of heat required to raise its temperature one degree, is high.

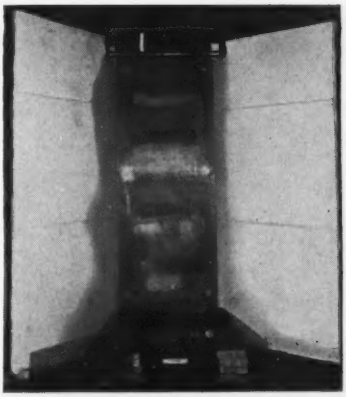
The ability of water to absorb and reflect radiant heat energy is not so well understood. Radiation occurs along almost any path that light can follow, including reflections and translucent obstructions. The sun's heat comes readily through the vast vacuum of interplanetary spaces. Yet, a simple test will show that water, in contrast to glass, though transparent to light, is peculiarly opaque to the infra-red rays that form heat radiation. When flame is viewed alternately through a thin piece of glass and directly, there is no appreciable difference in the amount of heat transmitted to the face. If, however, an unbroken film of water is caused to pass over the glass surface, the difference in heat transmitted through the combination is quite perceptible. The amount of light transmitted is not materially altered. This same effect can be observed in the quiet bodies of water, the deeper parts of which remain cool despite long periods of hot summer sun.

This peculiar property of water enabling it to resist heat radiation as well as heat conduction is an important factor in the use of water curtains as exposure protection, especially where the exposure is subject to oil and other fast burning fires. Underwriters' Laboratories recently made a preliminary investigation of its effect in this connection. The following description of the experiment is abstracted from the Underwriters' Laboratories bulletin on the subject, entitled "Opacity of Water to Radiant Heat Energy."

Description of Test Apparatus.

A steel plate ⅛ in. in thickness, 8 ft. in height, and 3 ft. in width was mounted vertically. The bottom of the plate was suspended 5 in. above the floor. Asbestos wing structures were mounted along the sides to confine the fire to the front of the plate. They also helped to maintain a uniform distribution of flame over the surface of the plate.

Nine thermocouples were mounted on the back face of the plate. Three were placed horizontally across the bottom, three across the center, and three across the top. The top and bottom rows of couples were placed approximately 1 ft. from the respective ends of the plate, and the outer vertical rows of couples were placed approximately 3 in. in from the edges. A supply of water from a slotted 2½-in. pipe mounted at the top of the plate provided a con-



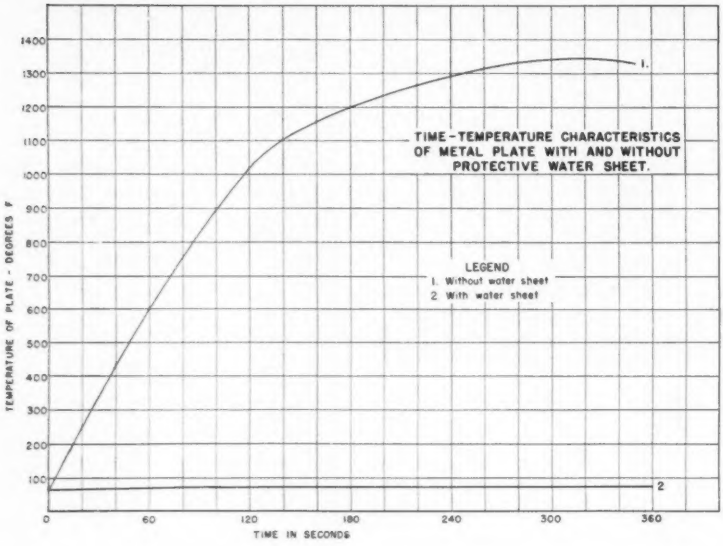
To determine the effect of water curtains, a steel plate was set up between asbestos wings, as shown above. It was flooded with a continuous water sheet from the slotted pipe at the top. Gasoline in the tank at the bottom was the fuel. Thermocouples at the back of the plate indicated temperature rise. The picture on the right shows gasoline flames completely enveloping the plate.

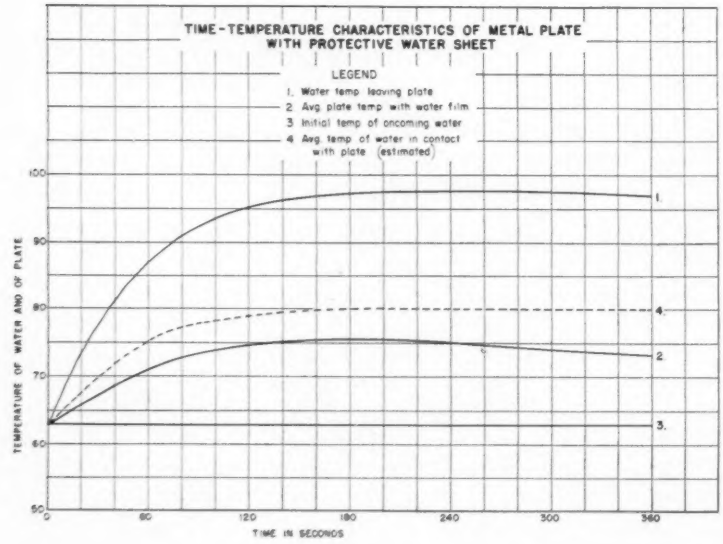
tinuous sheet of flowing water approximately 1/16 in. thick covering the surface of the plate except in the vicinity of the edges. The water was supplied at a uniform rate of approximately 45 gals. per min. Water temperatures were taken at the inlet and drain.

Ten gallons of gasoline were placed in a pan 3 ft. square and located 8 in. away from, and directly in front of, the foot of the plate, and ignited. The gasoline burned at a rate of approximately one gal. per min. during the first five minutes, producing flame temperatures in the order of 3000° F.

Tests were made for the same conditions with and without the protective water curtain. The purpose was to show that thin sheets of water would shield metal surfaces, and probably others from intense flame temperature. It was not intended as a measurement of the opacity of water to heat energy.

The temperature measurements obtained during each experiment are plotted on the accompanying charts. Temperatures at the vertical edges of the plate, however, are not included, since the flow of water in the vicinity of the edges did not provide a uniform and continuous coverage at all times. A curve


TIME-TEMPERATURE CHARACTERISTICS OF METAL PLATE WITH AND WITHOUT PROTECTIVE WATER SHEET.
LEGEND
1. Without water sheet
2. With water sheet
TEMPERATURE OF PLATE - DEGREES F
TIME IN SECONDS
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
60
120
180
240
300
360
1.
2


TIME-TEMPERATURE CHARACTERISTICS OF METAL PLATE WITH PROTECTIVE WATER SHEET
LEGEND
1. Water temp. leaving plate
2. Avg. plate temp. with water film
3. Initial temp. of oncoming water
4. Avg. temp. of water in contact with plate (estimated)
TEMPERATURE OF WATER AND OF PLATE
TIME IN SECONDS
100
90
80
70
60
50
0
60
120
180
240
300
360
1.
4.
2.
3.

of the estimated average temperature of the water in contact with the plate is also provided.

With the water curtain operating, the maximum increase in temperature at the top of the plate was 10° F., at the middle 14° F., and at the bottom 18° F. Without the curtain these temperatures were 1300°, 1440° and 1300° F. Thus the average maximum temperature rise was approximately 92 times greater without the water protecting the exposed surface of the plate.

The maximum temperatures at the top, middle, and bottom of the plate with the water flowing did not occur at the same time, while the maximum plate temperatures without the water were all observed at approximately the same time, five minutes after start of test.

Summary.

From the small rise in temperature of the protected surface, it was estimated that less than one per cent of the heat energy liberated by the fire, during the first five minutes of test, actually passed the water barrier. Approximately one-tenth of the total heat liberated was estimated to have been absorbed and carried away by the protective water sheet. The remaining nine-tenths was dissipated up the chimney or in other ways not affecting the protective sheet.

Confining attention, therefore, to the heat in contact with the surface under test, it is assumed that the major portion of the heat is either absorbed or reflected by the water surface. The water, flowing at the rate of 45 gals. per min., reached a constant maximum temperature at the outlet within two minutes after start of the test. The average temperature of the water in contact with the plate is shown by the charts to be approximately 5° F. above that of the protected surface.

The results indicate that as long as a water curtain is unbroken, and a sufficient quantity of water is employed, an inconsiderable quantity of heat will reach the protected surface from a fast burning oil fire. Although the test was conducted on a comparatively small scale, it shows in a general way what may be expected with fires involving greater quantities of fuel.

High or Low Pressure Fire Streams.

By Boris Laiming,
(Member N.F.P.A.)

In a recent article by Chief Folke,* the author discussed a series of experiments which in his opinion showed that volume rather than pressure of fire streams was the main factor in fire extinguishment. This has been a subject of controversy among European fire engineers and appears important from the point of view of proper construction of fire pumps and use of adequate fire streams capable of producing the best extinguishing results. In connection with Chief Folke's article, it seems interesting to review the evidence recently published** by one of his opponents, Engineer Johann Stanzig of the Vienna, Austria, Fire Department.

Experience of Vienna Fire Department.

Engineer Stanzig points out that the Vienna fire department has for many years recorded observations at actual fires and propounded the idea that the least possible volume of water but under the highest possible pressure is most effective in actual fire operations, and that his department has developed its equipment on the basis of that assumption.

Following Chief Folke's first publication of his experiments in Germany, the Vienna fire department conducted further investigations to determine the reason for the apparent discrepancy between the experimental results obtained by Chief Folke and the actual fire practice of the Vienna fire department.

It is an established fact, states Engineer Stanzig, that one kilogram (2.2 lbs.) of water absorbs a maximum amount of about 600 calories (2.4 B.T.U.) of heat, provided it can really be placed in a position to do so. Therefore, the point of contact of the water with the burning object, not the pressure, is the main factor. For the purpose of his investigation, Engineer Stanzig assumed that in the case of water dropping down on to a glowing horizontal plate, the particles of water thrown up into a spray would again drop back on to the plate. The unvaporized (residual) water would run off if the hot plate were slightly tilted.

On this basis, a series of experiments were made in which streams of water of equal volume, but under variable pressures, were thrown on to a hot plate, and the residual amounts of water and temperatures were recorded in

*"Experiments in Fire Extinguishment," by Chief Officer F. Folke, Fredericksberg, Denmark, Fire Brigade, N.F.P.A. QUARTERLY, Oct., 1937, Vol. 31, No. 2, p. 115.

**"Hochdruck und Niederdruck," by Ing. Johann Stanzig, Oberrat der Wiener Berufsfeuerwehr, Feuerschutz, Sept., 1937, No. 9, p. 145.

each case. The vaporized amounts of water under different pressures, ranging from 0.35 to 3.4 atmospheres, thrown on a plate at 900° C. (about 1650° F.), amounted to 50 per cent. Tests made with large cold plates showed 100 per cent recovery of the water in the form of residue, but when small cold plates were used 29 to 68 per cent of the water disappeared at pressures ranging from 0.1 to 4 atmospheres. This indicated, in the opinion of Engineer Stanzig, that smaller residues in Chief Folke's experiments corresponding to the higher range of pressures were due to the small size of the objects used in his experiments and to water dispersion.

Better Distribution with High Pressure Stream.

Engineer Stanzig expressed the view that where water thrown into a spray or dispersed by a high pressure stream remains within the heat range of a fire in the interior of a building or fire area it is much better utilized than the unvaporized run-off of a low pressure stream of similar volume, which causes greater water damage. Actual fire practice justifies this conclusion in his opinion. If the areas coming within range of a fire stream in a given period of time and the heat values are taken into consideration, it appears that the maximum useful amount of water at fires is relatively small. The object of a high pressure stream is to distribute this volume of water most effectively over the fire area. High pressure streams applied quickly over a fire area in a manner which allows the water to be rapidly vaporized break the intensity of a fire in short order by promptly reducing the dangerous temperature range which is the cause of the rapid spread of fires. Following this initial action, low pressure streams should be used, according to Engineer Stanzig, to bring the water to individual points where fire is still present.

The conclusions drawn from Engineer Stanzig's experiments relative to the value of high pressure streams as against low pressure streams were summarized by him as follows:

1, The percentage of water vaporized and turned into spray increases with pressure; 2, Water turned into spray vaporizes later; 3, A reduction of residual water minimizes the water damage; 4, High pressure application of water results in wider distribution of it and in a more rapid reduction of the fire temperature; 5, High pressure is advisable where distribution of the water over a greater fire area is needed; 6, Low pressure streams should properly be used to complete extinguishment of individual fire spots.

Effect of Pressure on Explosion Hazards.

By F. C. Mitchell and H. C. Vernon,
E. I. duPont de Nemours & Co., Inc. (Member N.F.P.A.)

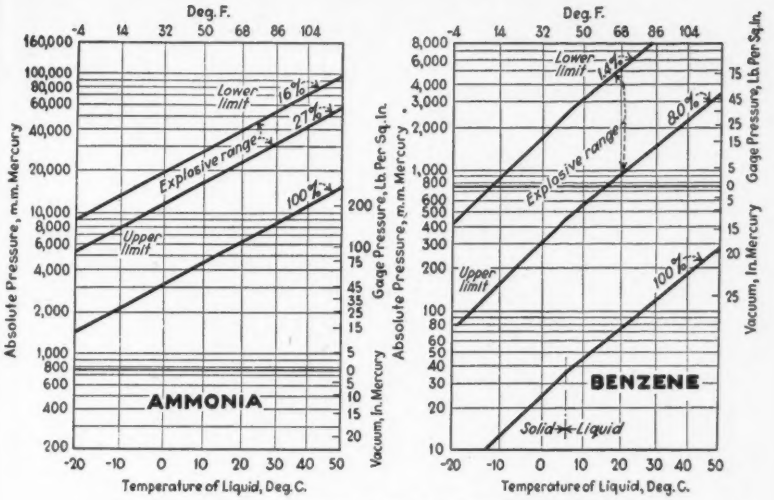
The explosive limits of flammable liquids as given in the N.F.P.A. pamphlet, "Fire Hazard Properties of Certain Flammable Liquids, Gases and Volatile Solids," and other standard references are subject to certain conditions which are not ordinarily understood. In the practical application of these explosive limits the temperature and pressure to which the liquid is subjected must often be taken into account. It can be shown that these factors have a pronounced effect on the explosion hazard, and are as important considerations in safe handling as are the explosive limits themselves.

It is easy to understand that the extent to which a liquid will vaporize is reduced when the pressure opposing this vaporization is increased and increased as the opposing pressure is decreased. In the same way, at a higher temperature the liquid will have a higher vapor pressure and will tend to vaporize in greater amounts. When, at a given temperature and pressure, the liquid has vaporized to the point where no more vaporization will occur unless conditions are changed, a state of equilibrium is said to be reached. It is evident that this condition cannot exist other than in a closed container, as in the open air a vaporizing liquid would continue to vaporize until the supply was exhausted. The pressure and temperature effect therefore is applicable only in tanks, pipes, and processing equipment in which the liquid and vapor-air mixture tend to approach equilibrium. In such cases the effect is shown graphically in the charts accompanying this article.

Explanation and Use of Charts.

The charts are based on the chemical principle that for equilibrium in a closed container partly full of liquid, the per cent of vaporized liquid in the air space above the liquid surface is equal to the pressure exerted by the vaporization (vapor pressure) of the liquid alone divided by the total pressure in the container. This percentage is also the unit in which explosive limits are commonly expressed. Therefore, assuming that a condition of equilibrium is reached, it is possible at any given temperature to calculate the pressures in the container at which the explosive limits are reached. The explosive limits are known and listed in "Fire Hazard Properties of Certain Flammable Liquids, Gases and Volatile Solids." There are tables of vapor pressure of liquids at given temperatures. The only unknown quantity in the relation is the total pressure in the container.

Presented under the title "Some Theoretical Considerations in the Safe Handling of Flammable Liquids" at the St. Louis meeting of the American Institute of Chemical Engineers, November 18, 1937.



Figs. 1-2. Explosive range charts of Ammonia and Benzene.

In the case of butane, for example, the lower explosive limit is known to be 1.5%. The vapor pressure at 0° C. (32° F.) is known to be equal to the pressure exerted by a column of mercury 790 millimeters (31 inches) in height or 15.3 pounds per square inch absolute. The pressure at the lower explosive limit is therefore computed as follows:

$$\text{Lower explosive limit } (.015) = \frac{\text{Volume of vapor alone}}{\text{Total volume of vapor and air}} = \frac{\text{Vapor pressure of liquid (790 mm.)}}{\text{Total pressure in the container.}}$$

$$\text{Total pressure in the container} = \frac{\text{Vapor pressure of liquid (790 mm.)}}{\text{Lower explosive limit (.015)}} = 52{,}700 \text{ mm. of mercury.}$$

$$\text{Total pressure in the container} = 1005 \text{ lbs. per sq. in gauge.}$$

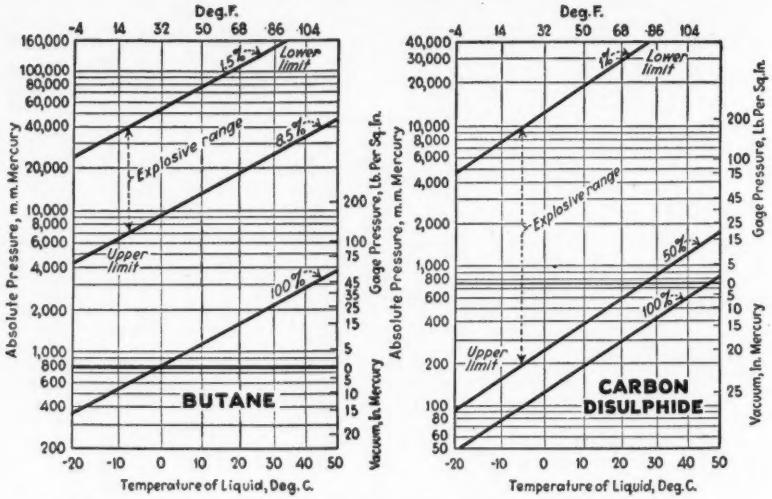
Since this is the pressure at the lower explosive limit, any increase in pressure will reduce the relative amount of vapor and move the mixture out of the explosive range. It will then be said to be "too lean" to explode.

The pressure at the upper explosive limit (8.5%) is similarly computed:

$$\text{Upper limit } .085 = \frac{v}{V} = \frac{790}{P}; \quad P = \frac{790}{.085} = 9300 \text{ mm. of mercury} = 165 \text{ lbs. per sq. in gauge.}$$

Any decrease of the pressure at this limit will cause the mixture to become "too rich" to burn.

From the above it can be seen that at 0° C. an explosive mixture of butane vapor and air will exist in a closed container if the pressure is between 9300 and 52,700 mm. of mercury, or between approximately 165 lbs. and 1005 lbs. per sq. in. gauge. If the pressure is less than 165 the mixture will be "too rich" to burn, and if more than 1005, "too lean" to burn. The pressures that will result at the explosive limits for each temperature can thus be deter-

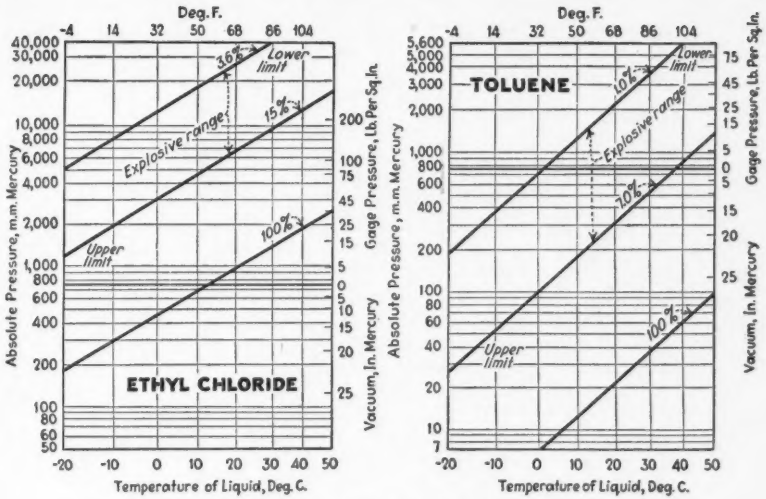


Figs. 3-4. Explosive range charts of Butane and Carbon Disulphide.

mined and shown by two lines on a chart, the area between which will represent the explosive range. Such charts for ammonia, benzene, butane, carbon disulphide, ethyl chloride and toluene over a temperature range from —20° to +50° C. (—4° to 122° F.) are included in these pages (Figs. 1-6). In all these charts the vapor-air mixture is assumed to be in equilibrium with the liquid.

Now, looking at the butane chart (Fig. 3), it can be seen that if the pressure is kept constant, say at 30,000 mm. (565 lbs. per sq. in. gauge), the lower or higher explosive limit can be reached by cooling the liquid to —14° C. (+6.8° F.) or heating it to 36° C. (96.8° F.) respectively. Butane then has an explosive range of fifty degrees at this pressure. Also from the chart it is evident that, over the temperature range —15° to 50° C. (+5° to 122° F.) a butane air mixture will always be in the "too rich" region if the pressure is below 5000 mm. (85 lbs. per sq. in. gauge). In practical application therefore, in any locality where the temperature does not fall below —15° C. (5° F.), liquid butane can be blown from one container to another by air at a pressure of less than 85 lbs. per sq. in. gauge without danger of creating an explosive mixture, providing equilibrium is established or nearly so.

Fig. 7 shows the lower explosive limits of some common flammable liquids and shows at any temperature the value above which the pressure must be maintained in order to stay in the "too lean" region. Fig. 8 is a similar chart of the upper explosive limits of the same liquids and shows at any temperature the value below which pressure must be maintained in order to stay



Figs. 5-6. Explosive range charts of Ethyl Chloride and Toluene.

in the "too rich" region. From these charts it will be seen that, in the region of the lower limits, increasing the pressure and decreasing the temperature makes conditions less hazardous, while in the region of the upper limits increasing the temperature and decreasing the pressure makes conditions less hazardous.

A tank partly filled with liquid ethyl chloride and air at a pressure of 40 lbs. per sq. in. is less hazardous at 30° C. than at —10° C. Conversely, toluene under air at a pressure of 40 lbs. per sq. in. is more hazardous at 30° C. than at —10° C. In similar manner, conditions within a storage tank of gasoline at atmospheric pressure, where the vapor-air mixture is in the region of the upper limits, are less hazardous in the summer than in the winter, while with crude oil at atmospheric pressure, where the vapor-air mixture is in the region of the lower limits, conditions are more hazardous in the summer.

Impurities tend to lower vapor pressures and so in effect lower the position of the explosive range. However, this will normally be of concern only in cases where the temperature and pressure conditions are already close to the upper limit and where any lowering of this limit might bring conditions into the explosive range.

Thus far consideration has been given to vapor-air mixtures in equilibrium with the liquid inside a vessel. When vapors are permitted to mix freely with air, as from an open vessel or a leak in a closed vessel, then equilibrium can no longer be obtained. The entire range of composition is experienced—from 100 per cent vapor and 0 per cent air at the liquid surface or at the leak,

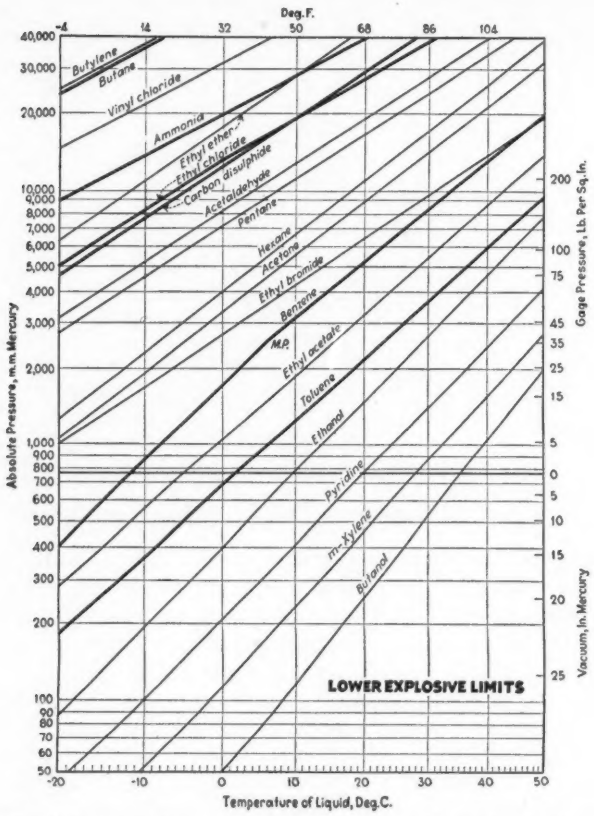


Fig. 7. Lower explosive limit chart for common flammable liquids.

to 0 per cent vapor and 100 per cent air some distance away. The only protection against such hazards is to reduce the volume of flammable vapors to an economic minimum by ventilation and, what is more important, reduce to a minimum all possible sources of leaks.

Flashpoints and Their Determination.

Flashpoint is defined as "the temperature at which a liquid gives off vapor sufficient to form an ignitable mixture with air." Flashpoints are measured at normal atmospheric pressure of 14.7 lbs. per sq. in. or 760 mm. of mercury absolute. It is known that the flashpoint of a liquid varies with barometric pressure at the same rate as does the boiling point of the liquid. Being by definition a measure of the minimum temperature at which sufficient vaporization

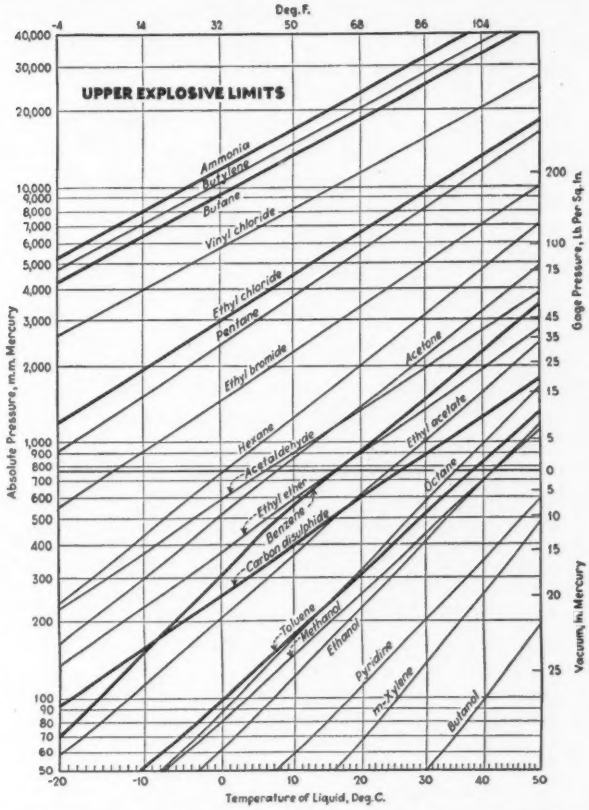


Fig. 8. Upper explosive limit chart for common flammable liquids.

occurs to form an ignitable mixture, flashpoint—at atmospheric conditions—should on the accompanying charts coincide with the intersection of the 760 mm. pressure line with the "too lean" or lower limit line.

The lower explosive limit line is then simply a measure of flashpoint over the whole pressure range. Failing to give flashpoint as a function of pressure may create a false sense of security, since the lower limit line shows that the point of entrance into the danger zone varies with pressure. It is known that under vacuum an explosive mixture is possible at a temperature much below the tabulated flashpoint of the liquid. Xylene has a recorded flashpoint of 28° C. (82° F.). Yet at 100 mm. pressure an explosive mixture will result at 0° C. (32° F.).

Safe Handling Methods.

The various methods by which liquids are forced from one tank to another, and the safety considerations involved in each, are given in the following paragraphs.

1. The use of a compressed non-condensible gas to displace the liquid in the tank which is to be emptied (Tank No. 1) is often a convenient and economical method. As already mentioned, air can be used wherever the total pressure of the air-vapor mixture at the temperature experienced does not enter the explosive range. The method has advantages over pumps or mechanical devices which may present sources of leaks. It is necessary, however, to bring the air into the vessel in such a manner that the explosive range is passed through quickly and safely.

2. Heating Tank No. 1 or cooling Tank No. 2 is a method which takes advantage of the differential in vapor pressure resulting from the change in temperature. Installation costs become excessive if steam or brine have to be brought from any distance. The method offers an advantage over air blowing in that there will be no loss on purging. Operating costs, however, will generally run higher.

3. Reducing the pressure on Tank No. 2 by applying suction is a method which entails considerable vapor loss unless a low temperature tailing condenser follows the tank. Air leaks in such a system may cause considerable loss of vapors along with the air that is carried out. If the reduced pressure is created by the suction of a compressor, which compresses the vapor from Tank No. 2 and discharges it back into Tank No. 1 without condensation, as in unloading ammonia or chlorine tank cars, a condenser is unnecessary. The main precautions here consist of holding stuffing box leaks to a minimum and keeping the pressure in the system below that of the upper limits of explosive mixtures.

4. Displacement of the liquid in Tank No. 1 by an immiscible liquid is a method which has been used with complete safety and high efficiency, as evidenced by the patented Aqua system of displacing gasoline with water. Here the storage vessel is kept entirely free of air space in which explosive vapors might accumulate, thus making it one of the safest systems of handling flammable liquids.

5. Pumping is undoubtedly the most familiar method for raising a liquid to a higher elevation and it needs no detailed discussion here. Pumps are usually economical to operate and entail low investment. Leaky stuffing boxes are frequently a source of hazardous vapor-air mixtures when flammable liquids are being handled.

In systems handling flammable liquids, lines coming from tanks or process vessels should always be fitted with slug or velocity check valves to

minimize loss and prevent unloading and loss of the entire contents of the tank in case the line is ruptured.

Ignition Temperatures.

It does not necessarily follow that whenever an explosive mixture exists, an explosion will occur. Combustion of flammable vapors will not take place unless the ignition temperature is reached and maintained, even though the liquid is hot enough to evolve vapors at a rate sufficient to produce an explosive mixture with air.

When excessive heat is produced, however, and is not dissipated at a sufficiently rapid rate, the temperature will rise and may reach the ignition point at which flame will result. Therefore dissipation of heat to avoid or control flame propagation is an important precaution in the handling of flammable liquids and vapors. It may be accomplished in several ways. In an internal combustion engine, the heat is removed as useful energy. In pipe lines, flash screens or flame arresters are used. These serve to conduct the heat to the pipe, from which it is dissipated to the surrounding atmosphere. Failure of some flash screens is often due to the lack of sufficient contact with the pipe for dissipating the heat to it. Tubular heat exchangers in a system have in many cases proven to be efficient flame arresters.

In conclusion, the following precautions to be observed in handling flammable liquids are emphasized:

1. Control the composition of vapor-air mixtures to avoid the explosive range.
2. Prevent the reaching of ignition temperatures.
3. Provide for the dissipation of excessive heat and so arrest propagation of flame.

Hotel Plaza Fire, Jersey City.

Report by Schedule Rating Office of New Jersey,
(Member N.F.P.A.)

Four persons lost their lives in a $15,000 fire at the seven-story fire-resistive Hotel Plaza, Jersey City, N. J., on December 29, 1937. The fire started when a spark from a miniature electric train ignited combustible decorations under a Christmas tree in the lobby on the first floor. All doors to one stairway were open, which allowed smoke and heated gases to spread to upper floors and trap guests in their rooms. Other contributing circumstances were a delayed alarm, an inadequate response on the first alarm, and congestion due to traffic and parked cars.

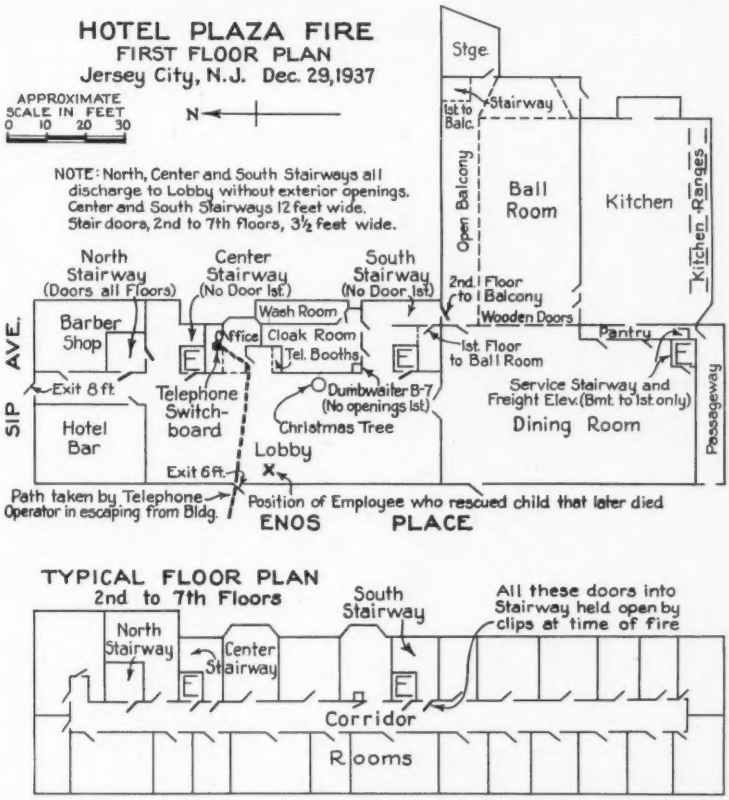
Construction and Occupancy at Time of Fire.

The Hotel Plaza is the city's largest hotel. It is a modern hotel of fire-resistive construction, seven stories and basement in height, and has 150 guest rooms. The arrangement of the first floor is shown by the accompanying sketch. Vertical openings consist of two elevator shafts, three stair shafts, and one dumbwaiter shaft. Openings to these shafts are protected by hollow metal doors, except that there are no doors at the lobby floor on the center and south stair shafts. Doors are self-closing on all stair shafts by means of door checks. In the south stair shaft, however, patented wall clips permitted these doors to be held open, and during a portion of each morning, while the rooms were being serviced, it was customary to fasten these doors open.

The lobby on the first floor is of ordinary room height, with no mezzanine. Also on the first floor are a dining room, ballroom, kitchen, and two mercantile occupancies, as shown on the floor plan. The lobby and dining room are separated by a light glass and frame partition. The ballroom is separated from the dining room by large wooden doors. Masonry partitions separate the kitchen and mercantiles from the dining room and lobby.

A typical floor plan of the upper floors is shown in the second sketch. There is one long corridor with rooms on each side. The two elevators and three stairways serve all corridors from the lobby. Guest rooms have either louvers or transoms, manually operated, for ventilation. At the time of the fire there were about 25 employees and 60 to 70 guests above the first floor.

Usual conditions prevailed at the time of the fire, except in the lobby and possibly the dining room, where decorations for the Christmas season had been put up. Apparently a considerable amount of the decorations were of a combustible nature. In the lobby was a large Christmas tree, trimmed to some extent with cotton. Under the tree, cotton was used freely to represent snow.



In this setting a miniature electric train was installed on a 5-ft. diameter track, operating from the house current by means of a small step-down transformer.

Story of the Fire.

At about 10:45 A.M. on December 29, 1937, two children were playing with the toy electric train under the Christmas tree when a short circuit occurred in the transformer connections or wiring. The resulting spark ignited the floor decorations, which in turn quickly ignited the tree. Two hotel employees who happened to be in the lobby promptly pulled the children from under the tree and rushed them to safety, but one child was severely burned and died later.

The hotel telephone operator, who was the only other person in the lobby, had plenty of time to escape without being injured, but it is reported that she

remained at her switchboard several minutes, ringing rooms and notifying guests of the danger. She died about three weeks later as a result of severe burns received as she escaped to the street with her clothing in flames. It was her screams and appearance in the street that gave first notice of the fire. It is said that outsiders sent in the first alarm by telephone. This "still" alarm at 10:54 A.M. is reported to have brought only one piece of fire apparatus. A second alarm was sounded at 10:58 A.M., and a general alarm at 11:03 A.M.

With the Christmas tree blazing, the combustible decorations, drapes and other furnishings in the lobby quickly reached their ignition temperatures, and the resulting large volume of smoke and heated gases vented themselves up the south stairway (all doors were open), mushrooming into the corridors of the various floors and trapping the occupants in their rooms. Rooms having louvers or transoms in a closed position afforded fairly good protection, but those having open ventilators quickly became untenable and the occupants were forced to windows for relief or possible escape. In many instances ventilators, either from disuse or due to several coats of paint, were stuck in an open or partially open position and thus could not be readily closed.

Many persons on lower floors escaped through windows by improvised life lines made of bedding. Many others were rescued by volunteers. Two telephone company men rescued six persons by placing a ladder on the roof of an adjoining building. Another man converted the halyards of a near-by flagpole into a lifeline and rescued four persons. A patrolman made many trips into the building, each time leading persons to safety until finally he was overcome. Heavy traffic in the neighborhood, parked automobiles on Enos Place, and overhead wires on another street handicapped to some extent the rescue work.

Upon the arrival of the fire department many people were still trapped at windows. All were rescued by means of ladders or life nets with the exception of a woman employee on the seventh floor. Due to weakness or fright, she failed to heed directions shouted to her and finally fell back into the smoke-filled room and was lost.

The fire on the first floor was soon brought under control. Only the lobby and dining room were badly damaged. Masonry partitions on the first floor, and good fire fighting prevented the lateral spread of fire. Fire-resistive construction prevented its vertical spread.

The fire department was handicapped by the delayed alarm, an open stair shaft, and other circumstances, but performed a creditable job, especially in life saving, with a total of 20 persons rescued by ladders and three or more by life nets.

Loss of Life and Property.

Two women, one man and a boy lost their lives. One woman, 51 years old, was the head maid. She was trapped in a room on the seventh floor and

Acme.

A spark from a toy electric train under the Christmas tree in the lobby of this fire-resistive hotel started a fire which took four lives in Jersey City, N. J., on December 29, 1937. A delayed alarm, an inadequate response to the first alarm, and doors to one stairway being open were contributing factors. Fire was confined to the lobby, but two persons were asphyxiated on the two top floors. Smoke may be seen coming from the lobby windows between the two doorways.

suffocated before firemen reached her. The other woman, 26 years old, was the telephone operator, who died about three weeks later from burns she received before or during her escape. The man, 24 years old, was employed by the hotel as houseman. He was asphyxiated on the sixth floor while attempting to warn guests and lead them to safety. The boy, eight years old, received fatal burns at the start of the fire under the Christmas tree.

About twelve persons were injured. Two persons who jumped into life nets from the sixth floor received sprained backs. One volunteer at a life net was hit and injured. The patrolman and one of the telephone company men, both of whom were active in early rescue work, together with several guests in the hotel, were overcome by smoke.

There was practically no fire damage above the first floor, except in elevator and stair shafts. There was no structural damage. Partitions, decorations, fixtures and the furnishings in the lobby and dining room were involved, resulting in a loss of about $15,000.

Conclusions and Recommendations.

A series of unfortunate circumstances occurred which might have produced a total property loss and a much longer casualty list had the building been of ordinary construction.

This fire illustrates the value of protected and properly maintained vertical openings. With proper maintenance (all doors closed) it is rather certain that no one above the first floor would have been endangered. Stair doors left open during servicing hours may be a rather common practice in hotels, but the management should not permit it and employees should be taught the purpose and importance of these doors as a safety provision. Doors that should normally be in a closed position might well be labeled as such, with a warning to report any violation immediately to either the management or the governmental department having jurisdiction. These labels might be unsightly, but not as unsightly as the trapping of human beings. A self-closing door with an automatic hold-open feature of approved type is the next best substitute.

In public or semi-public buildings such as hotels, Christmas trees, if not entirely prohibited, might readily be "fireproofed" to make them at least slow burning, or possibly artificial trees could be used. The use of cotton should be outlawed in the same way the old-fashioned Christmas candles have been. Supervision of such Christmas hazards, including temporary electrical wiring and the use of electrical toys, in public or semi-public buildings by the local fire department seems most desirable.

Just what part of the loss can be blamed on the delayed alarm cannot definitely be determined. At least it is not responsible for all the damage on the first floor nor the two lives lost there. However, it is possible that a prompt

alarm might have prevented the loss of the two lives on the upper floors. The delay is thought to have been from ten to fifteen minutes. Responsibility for the delay appears unknown. This fire also illustrates the weakness of a minimum "still" alarm response, probably sufficient for outside fires, but grossly inadequate for building fires. Good practice demands at least two engines and one ladder truck.

The two deaths from asphyxiation on the upper floors indicate the need for more positive acting mechanisms for operating ventilators or transoms, and shows the danger of placing sole reliance on such improperly arranged stairways for exits.

As a result of this fire the local fire department has been under criticism and the hotel is involved in two lawsuits. Consequently complete authentic information as to the circumstances of the fire is not available from these two sources at this time.

Coal Wharf Fire, Lynn, Mass.

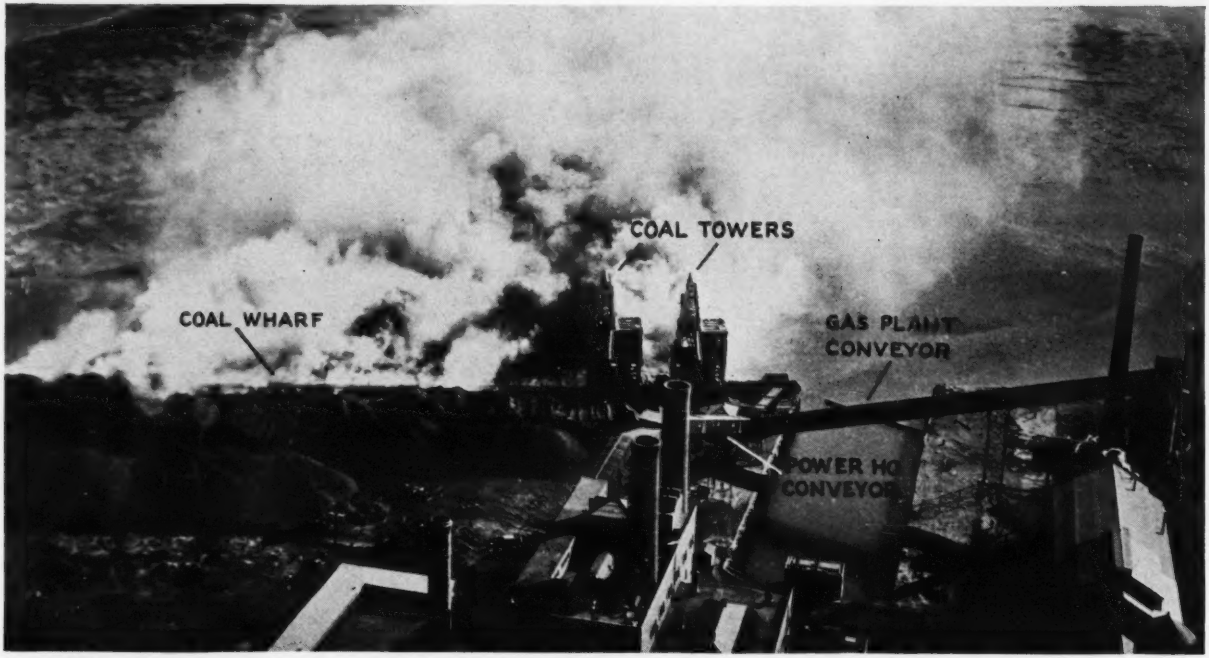
Fire starting under the wooden deck of a coal unloading wharf of the Lynn Gas and Electric Company, Lynn, Massachusetts, resulted in an estimated loss of about $500,000 on February 10, 1938. The fire spread almost unhampered under the wooden deck of this 650 ft. wharf. Attempts to use hose streams and cellar nozzles were ineffective, and the fire seriously damaged the wharf, destroyed two coal unloading towers, and destroyed or damaged several enclosed belt conveyors.

The arrangement of the wharf and conveyors involved in the fire is shown on the accompanying sketch. The coal wharf, built in 1926, consists of a 3-in. plank deck on heavy timbers supported on oak piling. The planking and timbers were creosoted and the wharf was in excellent condition except for unavoidable accumulations of coal dust between the planking and on the timbers below. The three hydrants at the wharf were equipped with hose houses and 2½-in. hose.

Story of the Fire.

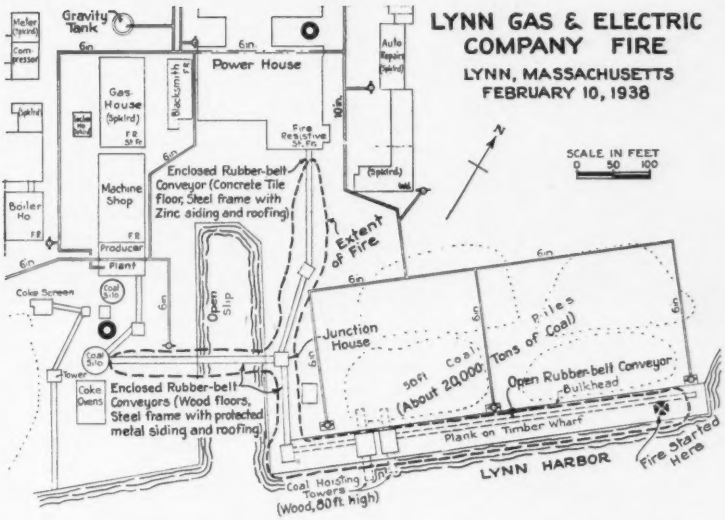
Shortly after 11:15 A.M. on February 10, 1938, the operator on one of the coal towers saw smoke coming up from between the planks near the northerly end of the wharf. He left his tower at once, notified the yard foreman, and turned in an alarm from a public fire alarm box on the premises. This alarm was

Note: This account was prepared from a report made by H. S. Walker and R. C. Corson, Engineers of the Associated Factory Mutual Fire Insurance Companies (Member N.F.P.A.), from observations of N.F.P.A. staff members, and from other sources.



International.

Air view of the half million dollar fire at the Lynn Gas and Electric Company, Lynn, Mass., on Feb. 10, 1938. The fire started under the wooden deck of the coal wharf and destroyed the two coal unloading towers. After this picture was taken, fire spread to the gas plant conveyor, causing it to collapse. The power house conveyor was damaged, but the fire was prevented from entering the power house in the foreground.

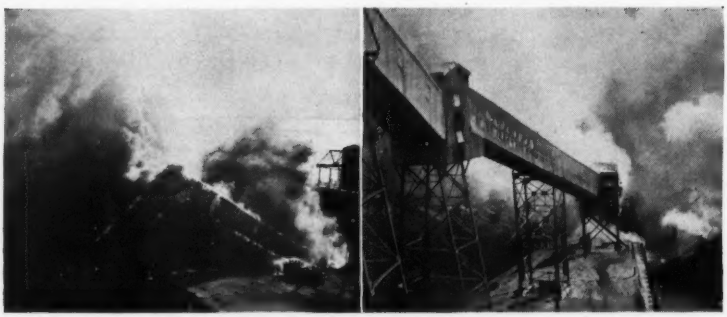


received by the fire department at 11:22 A.M. The yard crew ran a hose line from one of the hydrants at the wharf and directed a stream onto the deck whence the smoke was coming.

When the fire department arrived flames and smoke were issuing from under the northerly end of the wharf, and the firemen stretched their hose lines to either side of the fire, hoping to confine it to the area involved. A second alarm was sounded at 11:30 A.M., and with the reinforcements thus obtained streams were directed on the fire under the wharf from a raft and by means of cellar pipes inserted through holes cut in the wharf deck.

The stream from the raft was effective until heat and smoke made the position of the firemen on the raft untenable and they had to abandon it. They took to a small rowboat but it capsized, throwing them into the water and nearly costing their lives. The seven men were finally rescued by the Coast Guard. This episode, occurring during the early stages of the fire, apparently distracted attention from the fire fighting operations.

The creosoted planks and timbers and the accumulation of coal dust on the beams under the wharf produced a hot fire with dense black smoke, and it was soon apparent that the fire was spreading out of control under the wharf. A general alarm was sounded at 11:59 A.M., bringing the rest of the fire department and several pumpers from near-by communities. A fireboat also responded from Boston, and although it did not reach the scene in time to prevent the spread of the fire, it was of material help in extinguishing it.



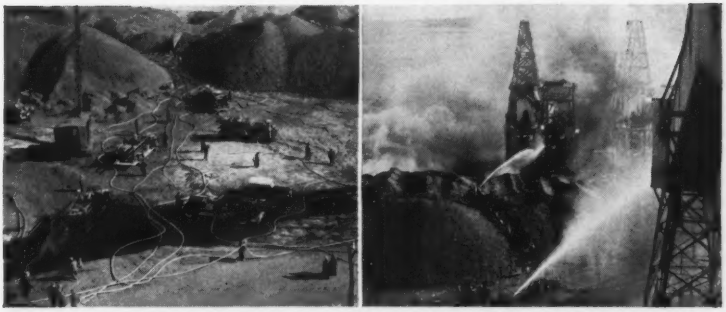
Photos Courtesy Lynn Gas and Electric Co.

Left: The gas plant conveyor at 1:10 P.M., a few seconds after it collapsed, just missing the fire department pumper in the foreground. Right: The power house conveyor at 1:11 P.M., showing sides melted out when fire spread up the conveyor. The upper portion was wet down by hose streams before the fire reached it and was not damaged.

A brisk northwest wind eddied around the coal piles and blew into the open northerly end of the wharf. The fire spread rapidly under the wharf by a series of puffs. Firemen tried to keep ahead of the fire by cutting more holes in the deck for use of cellar pipes, but as soon as a new hole was cut flames would come up through it. The water from the cellar pipes was effective in the area covered, but the location of holes did not permit stopping the lateral spread of the fire along the beams.

Just before 1 P.M. the fire reached a point under the two coal towers, which had previously been moved as far as possible from the fire and located close together about 100 ft. from the southerly end of the wharf. Ten minutes later the fire spread to the timber frame of the southerly tower, and about 2:00 P.M. this tower collapsed. The wooden framework of the other tower was badly burned but it did not collapse.

Apparently due to the danger of approach when the fire involved the two towers, the firemen fought the fire at this point from a distance and, almost unimpeded, the fire swept into the conveyor enclosures leading to the power house and the gas plant. Despite frequent cleaning, some coal dust must have accumulated in the interiors of these enclosures, because the fire progressed rapidly through them. The heat in the enclosures leading to the gas plant was so intense that the structure collapsed within five minutes, narrowly missing a fire department pumper stationed directly underneath. The protective coating of the siding and roofing was completely burned from the metal. The rubber belt was also consumed, although the wooden floor of this conveyor was not badly charred.



Left: Pumpers and hose lines between power house and wharf. Long hose lines were relayed by pumpers. None of the pumpers shown were connected direct to hydrants. Right: The burning coal-hoisting towers on the wharf at 1:34 P.M., just before one of them collapsed.

The fire in the conveyor leading to the power house was apparently not as intense as that in the gas plant conveyor, because there was no wooden floor and possibly less coal dust. The principal damage here consisted of the destruction of the rubber conveyor belt and the melting of part of the zinc siding and roofing. Employees, using a small hose stream supplied by a standpipe in the top story of the power house, and firemen with one hose line wet down the upper section of this conveyor and prevented the fire from entering the power house coal bunkers, where it might have resulted in additional serious damage. When the zinc siding melted and dropped out, hose streams from the ground were directed into the enclosure and may have helped to prevent the collapse of the structure.

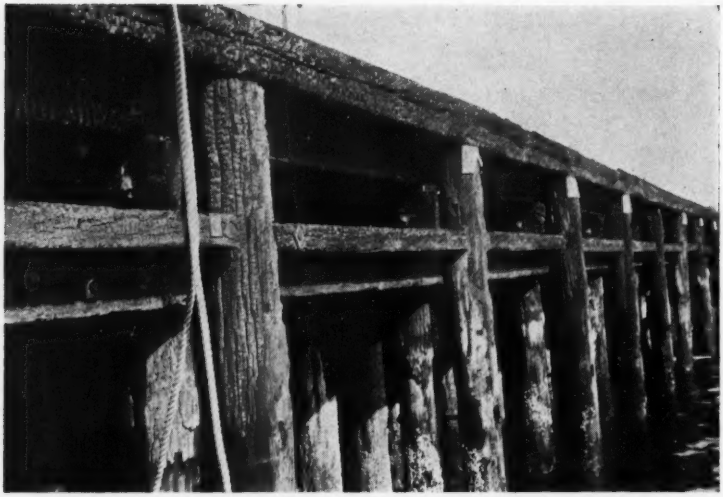
The fire was fought with hose streams supplied by 17 pumpers taking suction from various hydrants in the yard. Due to the long distance of most of the hydrants from the burning wharf it was necessary in many instances to pump in relay from one pumper to another.

Cause and Damage.

The cause of the fire is not known, although the careless disposition of smokers' materials seems probable.

The entire wharf deck will probably have to be replaced. Some of the heavy timbers beneath the deck and many of the diagonal braces and tops of piles were badly charred. Both of the coal hoisting towers will have to be replaced.

The conveyor leading from the wharf to the junction house was completely burned out, the wooden floor destroyed, and the steel members badly distorted. The gas plant conveyor collapsed and shows the effects of intense



Face of wharf after the fire, showing charred timbers and piling.

heat. Although the conveyor from the junction house to the power house was considerably damaged, it was placed in operation again 24 hours after the fire was out. Arrangements were immediately made to handle coal by means of trucks and portable cranes. There was no interruption of service from either the gas or electric plant.

Conclusions.

This experience illustrates again the difficulty of extinguishing fires in large wharf and pier structures with decks of plank on heavy timber and wood piling. The large areas of such combustible construction and the inability to apply hose streams directly on the fire present serious fire hazards. While this wharf was of relatively modern construction, the entire substructure was of creosoted wood without subdividing bulkheads or other fire stops, and there was neither any equipment for under-pier fire fighting, nor any special provisions to make the space accessible, as recommended by the N.F.P.A. Committee on Piers and Wharves. In the absence of such provisions for pier and wharf fire protection, it appears that a small motor boat equipped with a pump of at least 600-gallon per minute capacity and a monitor nozzle might have been effective in reaching the fire under the wharf.

Air Conditioning Fires.

Recent fires involving air conditioning installations have occasioned much current interest. In response to inquiries on the subject, the N.F.P.A. Department of Fire Record has prepared the following summary. These reports cover the significant fires in air conditioning installation reported to the N.F.P.A. since the publication of the last record on this subject in the QUARTERLY for January, 1936. These fires forcefully illustrate the importance of compliance with the N.F.P.A. Regulations on Air Conditioning, in most instances being clearly chargeable to features not in accordance with the Regulations.

June 3, 1936. Rochester, N. Y. Printing Plant.

A fire occurred in the dust at the foul air intake in the workrooms of the plant. Burning particles were drawn to the intake blower through the duct system, and finally ignited a steel wool air filter saturated with mineral oil. The heat from this burning filter melted the solder on seven banks of refrigerant tubing and released 350 lbs. of the refrigerant, dichlorodifluoromethane, which, however, caused no damage and did not affect the occupants. The system is of the recirculation type which takes air from the workrooms for its intake as well as some from the atmosphere, purifies it, and returns it to the workrooms. The fire was extinguished with hand extinguishers and the loss computed to be $955.

August 28, 1936. Denver, Colo. Radio Broadcasting Studio.

The ventilating and air conditioning ducts, concealed above fibreboard ceiling, were made of felted cork with oil binder. Several hours before the fire, smoke was noticed in the studio and its cause was unsuccessfully investigated. It disappeared and fire was not detected again until smoke was seen pouring out of the ventilators. The fire, started by a short circuit, was extinguished by the firemen with $5000 loss. The combustible ducts fed the fire and produced noxious gases which overcame several firemen.

September 17, 1936. Los Angeles, Calif. Clothing Store.

The twelve filters in the air conditioning system of this clothing store were made of paper supported in cardboard frames. After passing through the filters the air passed over the refrigeration coils and then into the store. It is thought that someone was smoking in the enclosed area containing the air conditioning machinery, and a spark entered the intake duct. The filters were ignited and destroyed, and the heat melted the solder on the coils, releasing the dichlorodifluoromethane refrigerant. This gas is nonflammable and will not support combustion. The smothering effect it had on the flames, together with the action of one sprinkler, extinguished the fire. The loss was reported as "considerable."

January 13, 1937. Rochester, N. Y. Restaurant.

A comparatively small air circulating and air conditioning unit in a restaurant was in operation for circulating air only. Filters were of steel wool saturated in a mineral oil called viscosine, which is flammable but has a high

flash point. Under draught conditions it can be readily ignited and burns with an intense heat. An employee of the installer's had just been oiling the blower when a spark, thought to have been caused by the extension cord he was using when it struck the steel housing, ignited a filter unit. Intense heat quickly unsoldered the refrigeration coil and liberated the dichlorodifluoromethane refrigerant. As soon as possible the operator shut down the blower motor and called the fire department. Smoke filled the restaurant, but fire did not spread to the felt lining of the discharge duct and did not damage the building. One of the three sprinkler heads in the room fused and practically extinguished the fire. The loss was variously estimated at $1600 to $2500.

February 8, 1937. Winnipeg, Manitoba. Radio Broadcasting Studio.

Alterations were being made on one floor of a telephone exchange building to accommodate a radio broadcasting studio. Included in the equipment was a self-contained air conditioning unit, separate from the general ventilation of the building. Fire started in the area which was practically air tight and built up considerable heat. The air conditioning unit was not operating, but some of the felt lining and wrapping used as a sound trap around the ducts was ignited and destroyed. The loss was reported to be over $30,000. There was $50,000 to $60,000 worth of broadcasting equipment involved.

April 9, 1937. Kansas City, Mo. Hotel.

A workman, attempting to weld an iron frame to the outside of a return air duct with an acetylene torch, ignited the combustible lining inside the duct. When the fire was discovered the blower system which normally induced a down draft in the duct was shut off and the fire and smoke then traveled upwards into the lobby. Three fire department hose streams and many chemical extinguishers were used on the fire before it was extinguished. It was necessary to open up the duct in one place in order to reach the fire with direct use of a fire stream. There was, besides the damage to the duct, considerable smoke damage to lobby furnishings, ceilings and woodwork. The loss was nearly $5000.

April 10, 1937. Rochester, N. Y. Newspaper Publishing House.

The building was equipped with separate air conditioning and exhaust systems. The air conditioning unit contained steel wool filters saturated with a high flash point oil and employed dichlorodifluoromethane as a refrigerant. Apparently a burning piece of waste paper from a remelting pot for type had been drawn into the exhaust system and ignited an accumulation of dirt inside the duct. This heated the air conditioning system, as the two ducts are close together for some distance. The heated air conditioning duct ignited dirt particles inside, which were carried to the filters. Fire apparently flashed through the entire area of the oil filters. The adjacent soldered copper cooling coils were unsoldered in many places. The refrigeration machines were not operating and most of the refrigerant was pumped back as far as practical to the compressors. A small amount of refrigerant escaped. Damage to exhaust and air conditioning systems was $1073.

June 11, 1937. Detroit, Mich. Department Store.

Fire originated in the blower room of the air conditioning system located in the sub-basement. The exact cause is unknown, but at the time the fire started workmen were welding braces in this room with an acetylene torch.

The fire started in the air filters, which were of the oil screen type with open tanks at the base, each containing about 1½ barrels of oil for flushing the screens. The fire spread rapidly through the filter screens to the open tanks, and while confined to the vicinity of the plenum chamber, considerable smoke passed to the upper floors through the outlet ducts. The fire department used three hose streams for about one hour before the fire was extinguished. About twelve sprinklers above and below the air ducts operated, but were of practically no value in controlling the fire, as it was confined within the blower and outlet ducts of the air conditioning equipment. The loss was about $21,200 to building and equipment and about $1200 to stock.

June 28, 1937. Shreveport, La. Bank Building.

This building is equipped with air conditioning units on alternate floors. A 20 h.p. motor driving a compressor on the ninth floor caught fire from overheating. The combustible fibre board insulation on the ducts immediately above the motor burned completely off. The damage, most of which was to the motor, was estimated to run between $300 and $400. An inspection the following day revealed that all of the 20 h.p. motors in the building were carrying their full capacity and were running very hot.

July 28, 1937. Holyoke, Mass. Alpaca Manufacturing.

Smoke and soot from a burning tar kettle in the yard was drawn through the air conditioning system into several manufacturing rooms in the third, fourth and fifth stories of the building. The soot was deposited on worsted yarn in process. About three hours' time was required to clean off all equipment and resume operations.

December 1, 1937. Paterson, N. J. Clothing Store.

Fire started in the basement boiler room, which contained two oil burners, air conditioning equipment and storage of boxes and other combustible materials. It is not known whether or not the air conditioning system was in operation. The store had been closed for two days prior to the fire. Apparently no one had been in the store during this period, but at least one oil burner was in operation. The fire apparently started at or near the burner, as the section of the first floor directly above was entirely burned out. The air conditioning machinery, consisting of refrigerating unit, air washing unit, steam coil, and ducts to the first floor, was located near the oil burners. The ducts were not directly connected to the furnace or oil burners, but they did help spread smoke and fire to the floor above. This system employed a recirculation of air with cold air intake at the first floor level, and exhaust outlets seven or eight feet above the floor.

Fire was largely confined to the basement and front section of the first floor, but there was considerable smoke damage throughout the two-story building and in two adjoining stores. Firemen experienced difficulty in gaining entrance, due to dense oil smoke and bars for burglar protection on windows. Six 2½-inch hose lines and booster lines were used. The loss was about $100,000.

December 30, 1937. Kansas City, Mo. Undertaking Establishment.

A fire, attributed to a cigarette, was discovered in the combustible lining of a return air duct of an air conditioning system. The lining, installed to deaden fan noise, extended only 25 ft. into the duct. The fire was extinguished by hose streams, and the short piece of lining removed.

Several hours later smoke was again discovered, this time issuing from the intake registers. The fire was found in the basement fan room involving the combustible insulation covering a warm air duct that crossed directly over the exhaust duct involved in the previous fire. The fire had spread to floor joists and an underfloor space. Sprinklers held it in check in the sprinklered areas, but it was necessary for the fire department to use a cellar pipe in the unsprinklered under-floor space. The loss was estimated at $7000.

January 19, 1938. Buffalo, N. Y. Restaurant.

A fire occurred in a filter unit of an air conditioning system. The filter consisted of glass fibres set in cardboard casings and coated with oil to trap dust particles. The fire was extinguished before damage had spread beyond the filter. It was thought to have been caused by a discarded cigarette.

January 31, 1938. Detroit, Mich. Department Store.

While employees were taking inventory after the store was closed, a fire started in the air conditioning system in an accumulation of waste paper scraps, lint and other refuse, presumably due to a cigarette discarded through the grille bars on the return duct intake located near the floor in the basement. This duct extends almost directly into a filter chamber in the sub-basement. The blowers were not in operation at the time.

Dense smoke filled the sub-basement, basement, first floor and mezzanine, which, due to open stairways, were all one fire area. Smoke also extended up the elevator, stair and pipe shafts, and apparently mushroomed into the ninth or top floor. Three sprinklers operated in the basement over the return register at the lunch counter and quickly extinguished the small fire involving a table and a millinery display. Twelve sprinklers operated in the sub-basement over the return by-pass filter chamber to the basement air conditioning unit, but could not reach the fire. There were no sprinklers inside the filter enclosures.

The actual fire damage was mostly confined to the interior of the intake side of the air filter chamber, consuming the accumulation of rubbish, oily lint and dust on the filter, but not extending appreciably beyond the discharge side of the filter. Smoke scented and discolored merchandise in the basement, first and ninth floors. The fire loss was estimated at $110,000.

Examination after the fire of part of the horizontal ducts in the discharge portion of the system revealed a serious accumulation of highly combustible lint and dust, covering about 35% of the floor of the duct. Had the system been in operation the heat of the rubbish fire would probably have ignited this accumulation and the loss would have been many times as severe, especially if the store had been crowded with customers at the time.

February 4, 1938. Washington, D. C. House of Representatives Office Building.

A workman was preparing to burn a hole in a chilled water line to relocate a water thermometer. He had lighted his acetylene torch and apparently the flame came in contact with an oil filter pad in the air conditioning system. This ignited the pad, which in turn ignited the other pads. Apparently the air conditioning equipment was not in operation at the time of the fire. Smoke went up through the ducts because there were no dampers in them. The workman tried to extinguish the blaze with an extinguisher he had with him at the job, but the fire spread so rapidly and became so hot that he was forced to leave. He went to a hose rack for the fire hose, but found it was too short. The extent of the loss was not reported.

Explosions in Dwellings.

Explosions in dwellings represent an important part of the annual fire waste of lives and property, as shown by the following record of 711 explosions, which killed a total of 1070 persons and injured 473 others. This record was compiled from reports of dwelling explosions on file in the N.F.P.A. Department of Fire Record covering the fifteen-year period from 1923 to 1937. While it includes only a small fraction of the total number of explosions, it is indicative of the general experience of explosions in dwellings. Due to the character of the reporting procedure, this record obviously includes an overbalance of explosions involving loss of life, as explosions where no lives are lost are less likely to be reported.

The percentage of the 362,200 dwelling fires and the resulting $103,200,000 dwelling fire loss in 1936 (see October, 1937, QUARTERLY, page 159) that may be attributed to explosions is not known, but the records indicate that a substantial part of the approximately 4500 lives lost in dwelling fires in 1936 resulted from explosions. (A record of dwelling fires appeared in the April, 1936, QUARTERLY, page 322.)

Explosions only are included in this record. Explosions of hot water tanks (where no fire followed) are excluded because they are not caused by a spark or other source of ignition. Neither does this record include explosions in apartments, rooming houses, or other multiple occupancy dwellings; so far as the records indicate the exact occupancy, this record is limited to single or two-family dwellings. It is often difficult to distinguish between flash fires and explosions, but as far as possible fires which were not accompanied by violent bursting or expansion with noise have been excluded from this record.

For purposes of this record, dwelling explosions have been divided into the indicated nine classifications. The table at the top of the next page shows the number of explosions in each class. The second table shows the number of deaths in each class of explosions.

One tragic aspect of needless explosions in dwellings is that more innocent children are killed than either the men or women who are generally responsible for such occurrences. As might be expected, 70 per cent (752 of the 1070) of those killed were women and children. In only two classes, home distilleries and miscellaneous, did the number of men exceed that of women plus children. Obviously, the operations implied by the other classes are largely performed by women or occur when the men are not at home, except in the fireworks and explosives class, where children and men are more often the victims.

Number of Explosions in Dwellings.
(15-Year Period 1923-1937.)

	Kind of Explosions	Number of Explosions
I.	Stove and lamp explosions	181
II.	Starting fires with kerosene	146
III.	Starting fires with gasoline	31
IV.	Home cleaning with flammable liquids	83
V.	Home distillery explosions	17
VI.	Miscellaneous flammable liquids explosions	103
VII.	City gas explosions	94
VIII.	Fireworks and explosives explosions	24
IX.	Miscellaneous explosions	32
	Total explosions	711

Loss of Life in Dwelling Explosions.
(15-Year Period 1923-1937.)

	Kind of Explosions	Number of Deaths				
		Men	Women	Children	No Data	Total
I.	Stove and lamp explosions	61	93	119	12	285
II.	Starting fires with kerosene	36	101	115	7	259
III.	Starting fires with gasoline	9	17	24	10	60
IV.	Home cleaning with flammable liquids	9	50	22	2	83
V.	Home distillery explosions	22	6	11	6	45
VI.	Miscellaneous flammable liquids explosions	46	36	56	4	142
VII.	City gas explosions	31	33	20	17	101
VIII.	Fireworks and explosives explosions	18	5	28	2	53
IX.	Miscellaneous explosions	18	6	10	8	42
	Total deaths	250	347	405	68	1070

Typical examples of each class of explosions are given in the pages which follow. The introductory paragraph to each section gives some idea of the most frequent causes of the explosions. The majority of dwelling explosions are caused by the misuse of kerosene and gasoline. Since the presence of explosive vapors is indicated by the class of explosion, and since the source of ignition is not always definitely known, it has not been found possible to tabulate the causes in each class. In the case of city gas explosions, however, an attempt has been made to list the reasons for the presence of gas. These typical examples of dwelling explosions indicate how simple precautions would eliminate the present needless loss of life and property by explosions.

I. Stove and Lamp Explosions.

The largest number of dwelling explosions in any one class occurred in oil stoves and lamps, including gasoline burning devices and a few cases of stoves burning other fuels. (Gas stoves and lamps, and explosions resulting from starting fires with kerosene or gasoline are not included.) Of the 181 ex-

plosions in this class, 134 occurred in stoves and 47 in lamps. Approximately 80 per cent of these appliances used gasoline for fuel—the remaining 20 per cent used miscellaneous kinds of fuel, such as kerosene, fuel oil, wood or coal, and in several reports the type of fuel was not specified. In addition to 285 persons killed in these explosions, 91 others were injured. As in the case of home dry cleaning explosions and explosions caused by starting fires with kerosene or gasoline, a large percentage of the deaths and injuries from stove and lamp explosions occur as a result of flaming flammable liquids being thrown over the victims' clothing. Sources of ignition are not usually known or reported; however, improper maintenance and lack of care during refueling and lighting operations were factors frequently noted. Typical examples of stove and lamp explosions follow.

WORCESTER, MASS., JAN. 6, 1926. An explosion of an oil heater that had been left burning behind a door in the front hallway caused the death of three people. The family was asleep on the upper floor of their cottage. When they reached the only stairway leading from the upper floor, it was a mass of flames. Four members of the family covered their faces and dashed down the stairs, while the others ran back to a bedroom. A neighbor saw the fire and went to their assistance. He raised a ladder to a second story window and assisted the occupants to the ground, but not before they had all been badly burned. Two women died almost as soon as they reached the hospital and a boy died during the afternoon. (L-0001.)

ALCESTER, S. D., NOV. 21, 1926. While a farmer's family was seated around a gasoline lamp in their home near this city, one of the boys attempted to pump up the pressure in the lamp while it was burning. The lamp exploded and sprayed the group with gasoline, setting fire to their clothing. An eleven-year-old boy ran from the house in search of his father. The wind spread the flames in his clothing, burning him so badly that he died within two hours. (L-0074.)

ST. PAUL, MINN., FEB. 16, 1928. A woman went to the basement to fix the furnace for the night. She had been burning soft coal and had shut the damper in the stovepipe. When she opened the furnace door to look at the fire the coal gas that had accumulated inside exploded. Apparently the flames killed her instantly, as her family heard no outcry. The only damage to the house was a few broken windows which the firemen broke to ventilate the basement. (L-0219.)

CULPEPER, VA., JAN. 21, 1929. An oil lamp exploded and set fire to combustibles in the room when a family of ten were retiring. The husband and wife were in a room on the first floor and escaped in their night clothing. Six of the eight children sleeping on the second floor were trapped by the flames and perished. The other two jumped out and were injured, but saved. The house burned to the ground. (L-0401.)

MARBLEHEAD, MASS., JULY 5, 1929. Explosion of an oil heater in a basement is thought to have caused the fire that totally destroyed two homes of a wealthy summer colony and most of their contents. Firemen from two neighboring cities assisted the local fire department, and while handicapped by a

International.

Two men sleeping on the first floor and one of the two boys in the attic of this Yonkers, N. Y., dwelling, were burned to death on Feb. 15, 1936, when a kerosene heater exploded. The heater had been left burning during the night and about 1 a.m. it exploded, scattering burning kerosene. (L-3469.)

shortage of water, they were successful in preventing the spread of the fire to other homes which were seriously threatened. The loss was estimated at $50,000. (H-35191.)

HOLBROOK, MASS., APRIL 11, 1932. Two small girls were burned to death in an explosion which occurred when a woman was refilling a kerosene oil stove. When she was about to replace the two-gallon glass bottle in the stand, she noticed a leak about the cap and attempted to place it on the floor to screw the cap on more securely. The bottle was slippery from the kerosene on the outside and it fell from her grasp and broke, resulting in the explosion. The two girls were covered with sheets of flame, and fire spread rapidly through the house, doing damage estimated at $3,000. The fire department was soon on the scene, but was unable to save the house. (H-35634.)

BOSTON, MASS., DEC. 2, 1932. Alone in the kitchen of her home, a woman suffered serious burns when her clothing ignited as a result of an explosion in a stove which contained a range oil burner. It is stated that flaming oil set fire to woodwork near the stove, and in attempting to extinguish the flames the woman's clothing ignited. The cause of the explosion was not ascertained. The kitchen was damaged to the extent of $500. (H-36584.)

PROVIDENCE, R. I., DEC. 18, 1932. Nine children and their parents were huddled around an oil stove in the kitchen. When one of the children leaned over and turned up the wick of the stove to get more heat, a terrific blast occurred, spraying burning kerosene in every direction. Two boys, six to eight years old, received the full force of the explosion and died of burns. The

parents seized blankets and smothered the flames that enveloped other children. The house did not catch fire. (L-1805.)

CHICAGO, ILL., AUG. 23, 1933. The father of a family on relief lighted the gasoline cook stove which he had converted from an old gas range. There was a blast and blazing gasoline was scattered over him, his wife and a small child. All three died later in the day. (L-2162.)

CHICAGO, ILL., FEB. 8, 1937. A woman was burned to death by an explosion of a fuel oil tank in the basement of her home. She had been supervising the delivery of fuel oil from a tank truck parked in front of the house, and apparently she lighted a match to read the measuring stick while the fumes were rising from the open oil tank. The explosion also collapsed one wall of the house and bulged out another. (L-3867.)

II. Starting Fires with Kerosene.

The second largest number of explosions in dwellings were due to starting fires or speeding up sluggish ones by applying kerosene to the fuel in a stove. This class covers 146 explosions in which 259 persons were killed and 51 injured. As indicated in the following typical explosions, the explosion frequently occurs in the kerosene can, but generally it appears that an explosive mixture of kerosene fumes and air accumulates in the stove before it is ignited by a match or smouldering coal. Ignition of clothing by the throwing of flaming kerosene from the explosion is a frequent cause of burns resulting in death. This scattering of burning kerosene about the room often traps the victims in the house.

BROWN'S MILLS, N. J., MAR. 11, 1927. A young mother got up during the night to heat some milk for her month-old daughter. Her father, who had not yet retired, poured kerosene on the smouldering embers in the kitchen stove to make the fire burn quickly. An explosion and fire followed, and in a short time the house was burned down. The man, four of his children ranging in ages from six to twelve, and the month-old baby were killed. Two other members of the family were badly burned in trying to rescue the children. A boy jumped from a second story window and was the only one to escape injury. (L-103.)

FT. DODGE, IOWA, AUG. 18, 1927. After filling the kitchen stove with kindling, a woman poured kerosene over it. The nearly empty can was in her hand when she lighted the fire. A burst of flame poured out of the stove and ignited the contents of the can. The can exploded and set fire to a door opposite the stove, but did not injure the woman. She ran out of the back door to safety and then returned to the kitchen, intent on saving her two babies who were asleep upstairs. While attempting to fight her way through the fire to reach them, her clothes caught fire and she ran outside again. Employees of an oil company across the street heard her cries and extinguished her blazing clothing, but she died a few hours later. The employees also removed the children from the house and extinguished the fire with extinguishers from the company's buildings. The damage to the house was slight, being confined to the kitchen. (L-0141.)

Acme.

An explosion caused this fire near Trenton, N. J., on Jan. 7, 1934, when a woman, mistaking gasoline for kerosene, poured it into the kitchen stove to revive the fire. Her two small girls were burned to death and the house burned down. (L-2347.)

STEVENS POINT, WIS., FEB. 23, 1934. A man was burned by an explosion of kerosene he was using to start a fire. He died five minutes later. His wife brought suit against the oil company, asking $10,000 for pain and agony suffered by her husband and $10,000 for the loss of her husband. The complaint alleged that death was caused by explosion of kerosene of a test higher than that permitted by Wisconsin statutes. The court rendered judgment against the company. (L-2934.)

JOPLIN, MO., DEC. 25, 1934. Kerosene used in an attempt to restart a fire that had not completely died out caused an explosion which resulted in the death of a mother and three children. It was Christmas and the family was in the dining room when the father tried to start the fire in the heating stove. The explosion cast flames in all directions. One of the children killed was a six-year-old boy on the second floor, who was suffocated. (L-2898.)

RAYMOND, NEB., SEPT. 19, 1935. A mother and her year-old son died on the way to a hospital as a result of a kerosene can explosion at their farmhouse. The can exploded when she was putting kerosene on the fire in the kitchen stove. Flaming oil covered her and the baby, who was toddling about on the kitchen floor. Neighbors extinguished the fire that was burning their clothing. The house was not badly damaged. (L-3299.)

CONNELLSVILLE, PA., DEC. 22, 1937. Three children, two men and a woman were fatally burned in their hundred-year-old log cabin on a mountain near Connellsville. The fire resulted from an explosion of a can of kerosene which the father was using to start a fire in the kitchen stove. The

rest of the family were asleep on the second floor and the blast ripped away the stairway, cutting off their escape. The cabin was destroyed. (L-4052.)

III. Starting Fires with Gasoline.

Sixty persons were killed and 19 others were injured in 31 explosions resulting from the use of gasoline to start or speed up fires in stoves. In nine of these explosions the persons using the gasoline thought it was kerosene. Explosion of the gasoline container is a common occurrence, as indicated by the following typical explosions.

WOONSOCKET, R. I., Nov. 3, 1934. Thinking that the fluid was kerosene, a girl, 17 years old, poured gasoline on the fire in the kitchen stove. An explosion blew the top off the can and sprayed flaming liquid over her. Her brother rolled her in a heavy rug and extinguished the flames, but she died from burns ten hours later. (L-2735.)

DAVENPORT, IOWA, FEB. 24, 1936. A can of gasoline, which she had mistaken for kerosene, exploded as a woman was using it to kindle a fire in the kitchen stove. Attracted by her screams, her husband rushed to the kitchen and found her clothing ablaze. He carried her outside and rolled her in a snowdrift, but she had already received fatal burns. (L-3981.)

WAYZATA, MINN., DEC. 18, 1937. While a father was starting a fire with gasoline, an explosion blew the top and bottom off the can. Neighbors heard the explosion and ran to the family's aid. When they arrived the house was almost engulfed in flames and the man's wife had thrown her three youngest children from the bedroom window and then crawled out herself. She was calling to her four-year-old twins to come out the window of another room, but they did not hear or were unable to get out. When the father recovered from the force of the explosion he carried the twins outside on a blazing mattress. The twins died the following day and the father died four days later. The dwelling was of concrete block construction, the interior of which was gutted, leaving only blackened walls. (L-4063.)

IV. Home Cleaning with Flammable Liquids.

A total of 83 deaths and 44 injuries resulted from 83 explosions caused by the use of flammable cleaning fluids in dwellings. Gasoline was used in 58 instances, and naphtha, benzine and miscellaneous fluids were used in the other 25 explosions. Clothes and other fabrics were being cleaned in the majority of the cases, while in a few instances other materials, such as furniture, bed springs, board walls, floors, and paint brushes were being cleaned at the time of the explosions. In the majority of the explosions the source of ignition was not given, but the most frequent sources reported were matches and smoking, stoves, gas pilot lights, static or friction sparks, and sparks from electric washing machines. While the records indicate that the loss of life and property damage average a little lower in home cleaning explosions than in other classes of explosions, the following typical examples show definitely that home cleaning with flammable liquids does not pay.

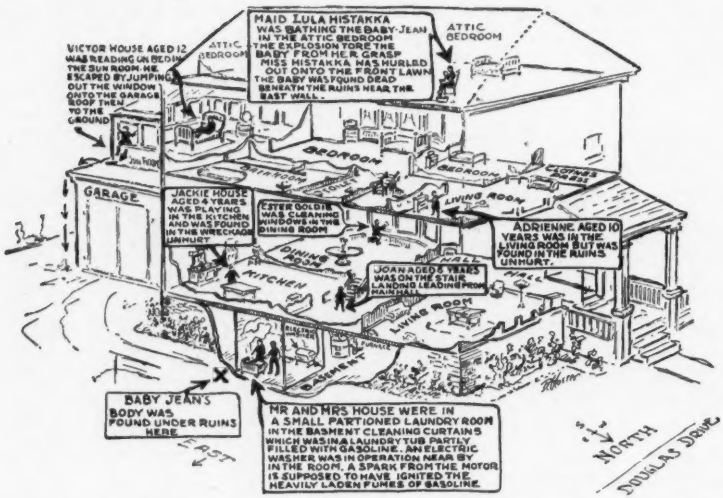

MAID LULA HISTAKKA WAS BATHING THE BABY-JEAN IN THE ATTIC BEDROOM THE EXPLOSION TORE THE BABY FROM HER GRASP MISS HISTAKKA WAS HURLED OUT ONTO THE FRONT LAWN THE BABY WAS FOUND DEAD BENEATH THE RUINS NEAR THE EAST WALL.
VICTOR HOUSE AGED 12 WAS READING ON BLOCK THE SUN ROOM HE ESCAPED BY JUMPING OUT THE WINDOW ONTO THE GARAGE ROOF THEN TO THE GROUND
ATTIC BEDROOM
ATTIC BEDROOM
GARAGE
JACKIE HOUSE AGED 4 YEARS WAS PLAYING IN THE KITCHEN AND WAS FOUND IN THE WRECKAGE UNHURT
ESTER GOLDIE WAS CLEANING WINDOWS IN THE DINING ROOM
BEDROOM
BEDROOM
LIVING ROOM
ADRIENNE AGED 10 YEARS WAS IN THE LIVING ROOM BUT WAS FOUND IN THE RUINS UNHURT.
DINING ROOM
KITCHEN
JOAN AGED 5 YEARS WAS ON THE STAIR LANDING LEADING FROM HALL
LIVING ROOM
BASEMENT
BABY JEAN'S BODY WAS FOUND UNDER RUINS HERE
MR AND MRS HOUSE WERE IN A SMALL PARTIONED LAUNDRY ROOM IN THE BASMENT CLEANING CURTAINS WHICH WAS IN A LAUNDRY TUB PARTLY FILLED WITH GASOLINE. AN ELECTRIC WASHER WAS IN OPERATION NEAR BY IN THE ROOM. A SPARK FROM THE MOTOR IS SUPPOSED TO HAVE IGNITED THE HEAVILY LADEN FUMES OF GASOLINE
EAST
NORTH
DOUGLAS DRIVE

Diagram of the dwelling in Toronto, Ont., in which three persons lost their lives as the result of an explosion from home dry cleaning with gasoline on Oct. 1, 1927. The locations of the people involved at the time of the explosion are indicated.

TORONTO, ONT., OCT. 1, 1927. A man brought home three 5-gallon cans of gasoline on Saturday afternoon to use in a washing machine to clean curtains. There was no fire or gas flame in the basement or anywhere near the small laundry where the washing was done, but there was an explosion which burned to death the man and his wife, who were in the basement, and a two-year-old baby, whose body was recovered by firemen from the ruins several hours later. Four other persons were injured. The supposed cause of ignition was an electric spark from the washing machine motor, although static electricity created by the friction of the curtains in the machine may have been responsible. The 12-room house was practically demolished by the explosion before the ensuing fire had gained any great headway. In addition, material damage was done to the adjoining dwellings on both sides. (L-0146.)

CHICAGO, ILL., SEPT. 6, 1928. A mother and her seven-year-old daughter were attempting to remove spots from furniture in their home with cleaning fluid. The mother was rubbing a soiled place on a davenport when the fluid ignited, apparently from friction. The daughter became excited and threw the can of fluid on to the fire. Both mother and daughter were enveloped in the resulting explosion and flames, and were fatally burned. (L-0840.)

STUART, VA., SEPT. 2, 1929. A young woman was critically burned when fumes from gasoline with which she was cleaning clothes exploded. She had placed a 2-gallon jar of gasoline near a kerosene lamp which ignited the gasoline fumes. The explosion blew out the windows of the house and tore down the plaster. (H-29678.)

Fumes from gasoline used for cleaning curtains in the basement caused an explosion and the damage shown above in this Salt Lake City, Utah, dwelling on May 13, 1928. (See April, 1932, Quarterly, page 409.)

The foundation of this dwelling in Fort Dodge, Iowa, was blown out and the house wrecked by an explosion on Oct. 30, 1931, when fumes from gasoline-soaked clothes and a pan of gasoline left to "settle" in the basement found their way to the furnace in which a fire was burning.

LYNN, MASS., MAR. 9, 1930. A woman was fatally burned when gasoline with which she was cleaning a dress in the dining room exploded. Her brother is reported to have been lighting a cigarette in an adjoining room at the time. The fire in the girl's clothing was finally smothered, but not until she had been so badly burned that she later died. Some time was lost in sounding the alarm and the fire spread through the house. The damage was $2500. (L-0513.)

HAVERHILL, MASS., AUG. 3, 1931. A man was fatally burned when a can of flammable cleaning fluid, which he was using in the kitchen of his home, exploded. Fumes from the fluid were ignited by the pilot light under a hot water heater. An attempt to save his life by jumping into the bathtub was unsuccessful. (L-1213.)

FORT DODGE, IOWA, OCT. 30, 1931. After cleaning some clothes in gasoline a housewife hung them up in her basement laundry. She also left the dirty gasoline to "settle" in the same room while she went to the movies with her two children. While they were gone the fumes from the gasoline-soaked clothes and the pan of gasoline on the floor found their way from the laundry to the furnace, where a fire was burning, in the adjoining room. An explosion followed which blew the foundation out from under the house. A sheet of flame shot through the interior, which completed the damage done by the blast. The house was a total loss. The woman who was responsible for the explosion told the fire chief that while she was aware that gasoline was very flammable and dangerous, she did not realize that the vapors were hazardous and was totally ignorant of the fact that they would ignite or explode. (H-34484.)

ALBANY, N. Y., APRIL 13, 1932. A woman was cleaning a rug with gasoline in the front room of her home. Her husband entered and struck a match. The gasoline fumes exploded, seriously burning the couple and their 20-year-old son. (H-34648.)

ELKHORN, IND., AUG. 6, 1932. A woman was using naphtha to clean clothes in the basement of her home. An explosion occurred while she was putting the cleaned clothes through the wringer of an electric washing machine. It is believed that friction from the rollers caused the clothing to ignite. Fire was largely confined to the laundry, due to her presence of mind in closing the door as she rushed from the flame filled room. She died from burns a few hours later. (L-1671.)

OTIS, KANS., JULY 5, 1935. A young woman was fatally burned and her husband was critically burned when gasoline which they were about to use for dry cleaning in the cellar of their home exploded late at night. The gasoline was in a two-gallon container, which was leaking, and vapor ignited from a lighted lantern. The resulting explosion blew the door firmly shut, trapping the couple in the blazing cellar until the man broke down the door. They went to a neighbor's house for aid, but due to the late time of night they called for a long time before they aroused anyone. (H-39827A.)

BEAUMONT, TEXAS, NOV. 28, 1935. A family moving into a house had drenched the plain board walls of a front room with gasoline to clean them. Heat from the smouldering embers in a stove ignited the fumes and caused an explosion. The man and his three small daughters were burned to death. (L-3201.)

HUGOTON, KAN., FEB. 14, 1936. One woman was burned to death and another was critically burned when gasoline, with which they attempted to clean clothes in an electric washer, exploded. The explosion threw flaming gasoline on the clothing of the two women (L-3374.)

V. Home Distillery Explosions.

The highest death rate per explosion is found in home distillery explosions, where 45 persons were killed and seven were injured in 17 explosions. Following are two examples of still explosions.

ANSONIA, CONN., AUG. 26, 1925. One man was killed and another seriously injured as the result of an explosion of a 100-gallon still in a frame dwelling. The flames which followed did about $5000 damage to the house. (H-22482.)

WEST NEW YORK, N. Y., MAY 3, 1935. Explosion of a large still in the basement of a frame house caused the deaths of a man and a woman. The fire was fed by alcohol from the still and rapidly burned down the building. An automobile in the front yard was also destroyed. Firemen prevented the flames from spreading to adjoining buildings. (L-3089.)

VI. Miscellaneous Flammable Liquids Explosions.

The use of flammable liquids in dwellings for purposes other than those indicated in the foregoing classes caused 103 explosions which resulted in the death of 142 persons and injuries to 33. The fluid was gasoline in 50 per cent of the explosions, kerosene in 25 per cent, and other fluids, such as alcohol, oil, naphtha and carbon bisulphide in the remaining 25 per cent. Three explosions resulted from placing cans of kerosene or gasoline on the stove to heat.

Wreckage of a home in Jackson, Mich., resulting from the use of gasoline in an electric washing machine in the basement. No fire followed the explosion, but a man and a woman lost their lives when stunned by the blast and trapped in the wreckage. The fumes were ignited by an electric spark after a blanket became wedged in the wringer. (L-3768. See October, 1936, Quarterly, page 138.)

Three explosions resulted from fumigation or insect destroying processes. Three explosions occurred when floors were being renovated. Causes of other explosions were different in nearly every case. Typical examples follow.

LAWRENCE, MASS., MAR. 31, 1928. Workmen had just finished laying a composition floor in a basement-kitchen when a man entered and pulled the electric light chain. The chain broke, so he struck a match to find the trouble. There was a terrific explosion which covered the man and a woman (who was cooking in the kitchen) with flames. They tried to escape but were hampered by a peculiar suffocating smoke. Someone passing the house noticed the fire and turned in a fire alarm. Firemen responded and removed the man and woman, and carried a lame man from the second floor to safety. The composition material contained either gasoline or ether. (H-25823.)

PLEASANTVILLE, N. Y., MAY 15, 1928. Fire, believed to have started by a spark on the wooden shingle roof, burned to the ground a $15,000 dwelling on the outskirts of this village. Three volunteer fire companies were unable to save the house because of lack of water, but they did save the adjoining dwellings, the dry shingle roofs of which were showered with sparks. Only the chimneys were left standing when an explosion sent burning wreckage and

The gas explosion that wrecked this home in Canton, Ohio, on May 26, 1926, also blew the owner through the wall, but he escaped serious injury.

flames fifty feet into the air and endangered the lives of about fifty firemen. It was a tank which had been used as a reserve supply for the oil burner that exploded. The oil burner had been taken out of the building a year before, but this tank remained. The 300-gallon tank buried outside the building, which had been used as the main supply, escaped the flames, but this smaller tank in the cellar had never been drained, and exploded. (H-26050.)

NEW ORLEANS, LA., JULY 25, 1929. Carbon bisulphide had been used by an engineering company to destroy termites in the basement of a large residence. Some 45 holes had been drilled in the floor and about 45 gallons of carbon bisulphide was poured in them. About one and one-half hours after the pouring was completed there was an explosion which wrecked the building. Fire followed, but was soon extinguished by the fire department. Loss to the building was about $13,000 and to contents about $6000. The man in charge had taken various precautions against possible sources of ignition, such as cutting off the water heater and its pilot light, but apparently he did not shut off the refrigerator motor in the basement. The machine was located where the explosive vapors were most likely to accumulate. The ignition was presumably from the switch or the commutator brushes of the motor. (H-33170.)

DETROIT, MICH., DEC. 3, 1931. A father, two daughters, and their girl friend were severely injured by the explosion of a two-gallon can of gasoline which had been left uncorked in the kitchen of their dwelling. Unaware of the presence of gasoline, the father entered the kitchen with a lighted cigarette. The explosion threw burning gasoline on himself and his daughters' friend. The two daughters were hurled through the kitchen door. (H-35282.)

KEARNEY, N. J., FEB. 18, 1932. A 20-year-old boy had placed some automobile parts in a can of gasoline and left it with his brother's three small children in the kitchen while he went outside for a moment. He ran back to the house when he heard an explosion and saw flames in the kitchen windows. He met one of the children at the door, dragged him out, and then ran into the kitchen to get the other two, but they had already been led to safety by their parents. The boy never came out and firemen could not enter because of the heat and flames. His skeleton was found under the kitchen sink after the house had been destroyed. Fire officials thought the pilot light on the kitchen stove might have ignited the gasoline fumes in the room, causing the explosion and fire. (L-1471.)

YREKA, CALIF., OCT. 25, 1932. A man heated gasoline in a pan. When it exploded and set fire to his clothing he threw the pan through the doorway into the yard. A small boy sitting near the door received the flaming gasoline on his body. The man, disregarding his own plight, attempted to assist the boy, but the boy died that evening and the man the next day. The gasoline was heated for use in manufacturing a mixture to waterproof canvas. (L-1828.)

UNIONTOWN, PA., DEC. 2, 1935. Holding a glass container of stove polish in his left hand, a man started to polish a hot coal stove with his right hand. The brush ignited and flames leaped to the polish. Just as his wife entered the room the container exploded and threw flaming liquid over her. She died from burns two hours later. The man was severely burned in attempting to extinguish the flames in her clothing. (L-3401.)

ST. AMBROISE, QUEBEC, DEC. 5, 1936. Seven children and their convalescing mother, who died in a vain effort to rescue her family, were burned to death when flames from a gasoline explosion swept their farm home. The explosion occurred when a dog knocked over a can of gasoline in the small cook shed and a member of the family investigated the noise by lighting a match. The house was a mass of flames at once. The father fought his way to the attic, where he found his wife overcome by smoke. He took the baby from its mother's arms and tossed it from a window into the deep snow. He tried to carry his unconscious wife to safety, but was too weak, and with his clothes afire, he was forced to escape. All the other seven children were cremated in their beds. Only the burning débris, heaped in the foundations, remained when neighbors reached the scene. (L-3769.)

VII. City Gas Explosions.

In view of the widespread use of city gas for domestic cooking and heating, gas explosions in dwellings are of relatively infrequent occurrence. Once a house is filled with a mixture of gas and air any one of dozens of possible sources of ignition may cause an explosion which demolishes the house and perhaps damages adjoining property. This record includes 94 gas explosions in dwellings, in which 101 lives were lost and 189 other persons were injured. In 34 of these explosions property losses were either complete or large. Actual loss figures, given in the reports of 16 fires, indicate an average property loss of $18,000 per explosion. In four explosions a total of ten dwellings were completely destroyed and seven others were damaged.

The following table shows the causes of the gas explosions or how the gas escaped into the dwellings.

Cause	Number of Explosions
Gas leaked into house from street main or service pipe	15
Kitchen gas stoves, explosions in ovens, etc.	9
Attempts to relight after burners went out	7
Explosions when lighting gas burners	7
Explosions of gas heaters	6
Gas in room ignited by striking matches	4
Leak in gas meter or pipe near meter	4
Attempts at suicide by turning on gas	3
Gas in room ignited by kerosene lamp or gas pilot	3
Looking for gas leaks with matches	3
Careless operation of gas appliances	2
Gas entered house by water service pipes	2
Leak in gas main while being worked upon	2
Lightning ignited gas	2
Pipe connections to heaters broke	2
Boys trying to stop leak in gas pipe	1
Excessive pressure in gas main	1
Gas in house ignited from burning leaves outside	1
Gas in room ignited when electric lights turned on	1
Pilot light went out in gas furnace	1
Shut off wrong meter when installing gas stove	1
Steam shovel broke gas service pipe	1
Struck gas pipe while digging well in basement	1
Unknown	15
Total	94

The records indicate that about 50 per cent of the gas explosions originate in basements, 35 per cent in kitchens, and 15 per cent in other parts of dwellings. The following are typical examples of gas explosions in dwellings.

EL MONTE, CALIF., MAR. 27, 1924. Gas from the gas main, under 60 to 80 lbs. pressure, leaked out of the governor or reducing gauge on the gas meter in a dwelling. The hissing noise awakened the family at 4:30 A.M. The owner of the house realized the danger and warned his wife and daughter not to strike any matches and to get out of the house while he went next door to call the gas company. Fortunately everyone was outside when the accumulated gas came in contact with the pilot light on a gas heater and set off the explosion which demolished the house. No fire followed. The force of the explosion broke several windows in the neighborhood. (H-23803. See October, 1926, QUARTERLY, page 150.)

CANTON, OHIO, MAY 26, 1926. The street was being graded and widened when a steam shovel came in contact with a gas service pipe, bending it. A street ell located about 18 inches from the basement of a dwelling was broken in two. Apparently a considerable amount of gas escaped into the

Lighting a cigarette in a gas-filled house caused the explosion which blew out three walls of this dwelling in Los Angeles, Calif., on Nov. 23, 1935.

basement and worked up inside the walls of the frame dwelling. Undoubtedly the gas became ignited from the fire in the furnace, resulting in an explosion which wrecked the building. No fire followed. It is reported that the gas company rebuilt the house for the owner. (H-23803. See October, 1926, QUARTERLY, page 151.)

ST. PAUL, MINN., AUG. 25, 1926. For three days a man had complained of leaking gas in his $28,000 brick veneer and stucco house. The gas company had dug several holes along the street about a block away, but had not been able to locate the leak. About 4:00 P.M. the smell of gas became much stronger in the house and the man's wife became alarmed and took her four small children to a neighbor's house. In about fifteen minutes after they left there was a terrific explosion which wrecked the house. For about five minutes flames burned on the ground in the street where workmen had been digging. Flames swept through the house, but about fifteen minutes later the fire was under control. However, it had already done serious damage to the interior and practically destroyed the furniture. Upon investigation, it was found that there was a hole about three-quarters of an inch in diameter in the street main not far from the gas pipe leading into the house. It is believed that gas from this hole followed the line of least resistance through the loose sand and gravel soil along the gas pipe leading into the house. When the gas and air mixture reached the right proportion in the house it was probably ignited by the gas pilot light of the hot water heater or gas stove. (H-32480. See October, 1926, QUARTERLY, page 148.)

International.

Three persons were killed and five others injured when their ranch home at Lodi, Calif., was completely demolished by a gas explosion and fire on July 16, 1936. The explosion occurred when a member of the family went to the basement to light a gas heater which had been leaking. An automobile overturned by the blast is in the background. (L-4017.)

PEABODY, MASS., NOV. 7, 1928. An explosion occurred when a man looked for a gas leak in the basement of his home with a lighted cigarette in his mouth. The blast wrecked the basement. (H-26817.)

NORTH TONAWANDA, N. Y., NOV. 28, 1930. The owner of a dwelling was trying to repair a gas leak in his basement, when the pipe pulled apart. He ordered his family from the house and summoned the fire department. The firemen entered the basement and opened the windows to allow the gas to escape. After they returned to the outside, an explosion occurred due to ignition of the gas by the furnace. The building was wrecked. One fireman was killed by flying débris and six other firemen and four civilians were injured. (L-0924.)

PITTSBURGH, PA., FEB. 11, 1930. A woman apparently had lighted a gas stove in her bedroom and left the room. When she returned it had gone out, and when she struck a match to relight it an explosion shattered the windows in the room and set her clothing on fire. She died from burns. (L-0533.)

LATONIA, KY., JAN. 6, 1931. One woman was killed and two others were injured as the result of a gas explosion that wrecked one dwelling and badly damaged four others. This woman had gone to the cellar to put coal in the furnace. When she opened the furnace door an explosion threw live coals over her, igniting her clothing. A simultaneous explosion occurred in the adjoining house, which partially collapsed. A leak in the gas main in the street was blamed for the explosion. (L-1040.)

BERKELEY, CALIF., DEC. 3, 1931. A gas service pipe entering the basement of a dwelling had been capped after the house was destroyed in the 1923 conflagration. When the new house was erected on the old foundation a new service pipe was installed. The odor of leaking gas had been apparent for some time, and the son of the owner and a companion went to the basement to

This dwelling in Merion, Pa., was practically wrecked in a gas explosion on Nov. 30, 1937. Excessive pressure in the gas main caused gas to accumulate in the basement.

investigate the source of the leak. They concluded that gas was escaping around the cap of the disused pipe. They attempted to tighten the cap, but being unable to do so they turned it in the opposite direction, intending to put white lead in the screw threads. The cap blew off and they could not replace it. They were also unable to turn off the pilot light in the gas furnace. When the escaping gas reached the pilot there was a mild explosion. The gas from the uncapped pipe ignited and set the basement ceiling on fire. The fire department was called and the blaze was extinguished, but the boys forgot to tell the firemen about the uncapped pipe, and the gas continued to flood the basement and the house. Thereupon the chief ordered the gas shut off at the meter, but finding that the uncapped pipe was not connected to the meter, he ordered the pipe capped. In the meantime windows and doors had been opened and a highly explosive mixture of gas and air had formed. A spark or smouldering ember ignited it and a terrific explosion resulted. The dwelling was wrecked, the adjoining house was badly damaged, and a fire truck in front of the house was buried in the débris. Flames broke out in the wreckage. Fifteen firemen, who were inside the house at the time of the explosion, were seriously injured, two so badly that they died later. One bystander was killed and forty-six other persons were injured by flying débris or burned by the blast. A father of one of the firemen, slightly injured by the explosion, died from shock when learning that his son was in the explosion. (L-1436. See January, 1932, QUARTERLY, page 326.)

LOS ANGELES, CALIF., NOV. 23, 1935. A man dressed in the morning to go to work, and as he left his bedroom he lit a cigarette. An explosion fol-

One block away from the first dwelling that was wrecked by a gas explosion in Merion, Pa., on Nov. 30, 1937, this dwelling was completely demolished by a similar explosion just three minutes later.

lowed, blowing him out of the house. Upon questioning him at the hospital, investigators from the city arson bureau learned that he thought he smelled gas when he came home from a party the night before. He said that he disconnected the two gas heaters in the house, both of which were connected with rubber hose. Apparently the gas continued to leak after he retired. Three walls of his one-story frame dwelling were blown out, with a loss of $1200 to the building and $200 to contents. (H-42336.)

NEWTON, MASS., OCT. 29, 1937. A gas explosion, probably caused when someone struck a match to light a gas oven on the second floor, practically wrecked a dwelling. Twenty-two persons were injured—either buried in the débris or injured in rescue work. The blast was heard over an area of five square miles. Plaster fell from the walls of many buildings in the vicinity, and several windows were shattered in adjoining dwellings. Apparently gas seeped along the service pipe and into the house. One of the occupants, who suffered a broken leg in the explosion, stated that they had smelled gas in the house for several weeks before the explosion and had notified the gas company. Company men attempted to find the leak, but they encountered difficulty. The smell persisted. Shortly before the explosion service men had installed a new prepayment type gas meter. (H-42198.)

MERION, PA., NOV. 30, 1937. Between 1:22 P.M. and 1:25 P.M. gas explosions occurred in two widely separated dwellings and escaping gas was detected in two other dwellings. Prior to the explosion in the first dwelling at 1:22 P.M., employees heard hissing noises in the basement, and upon investigation they found the gas concentration in the basement so great that they had to leave. The fire department and the gas company were called. Firemen entered

and shut off the gas heater. They left the basement to put on their gas masks and had just re-entered when an explosion occurred which practically wrecked the house and injured some of the firemen. Meanwhile, gas was detected in the second dwelling, which was more than a block from the first dwelling, and while notifying the fire department an explosion occurred at 1:25 P.M. which completely demolished the house, indicating that the gas had spread throughout the walls and partitions. The occupants escaped with injuries. Prior to and during these two explosions two other households in the neighborhood heard hissing noises or smelled gas. So far as could be learned all four homes were heated with gas and equipped with gas hot water heaters, all appliances being in good condition. The gas company in a newspaper statement indicated that the explosions were caused by negligence of an employee who failed to properly regulate a valve controlling pressure in the mains, and as a result permitted excessive pressure to exist. Apparently this excessive pressure disrupted the gas meters and caused gas to leak into the dwellings. The total property damage was estimated to be around $100,000. No fires followed the explosions. (H-42337.)

VIII. Fireworks and Explosives Explosions.

Fifty-three persons, over one-half of whom were children, were killed and ten were injured in 24 explosions involving fireworks or other explosives in dwellings. Homemade or toy cannons caused four explosions. Gunpowder caused three explosions, one of which occurred when a man threw some into a stove thinking that it was coal dust. Several explosions were of various types of fireworks being set off in homes. The following examples are typical explosion of this class.

BALTIMORE, MD., JAN. 27, 1932. Two boys were working with a combination of sulphur, charcoal and potash in an attempt to make an explosive that could be used to uproot a tree stump in the yard. The explosion wrecked the cellar where they were working and broke all the windows in the house. One boy was killed and the other was badly burned. (L-1659.)

WATERLOO, IOWA, JULY 4, 1933. Three persons were injured, one fatally, when a homemade cannon exploded in a dwelling. A man had emptied powder from firecrackers into the cannon and was packing it in with a hammer and chisel when a spark set off the explosion. His left hand was shattered. Part of the cannon passed entirely through the body of his two-year-old daughter. She died two hours later. A ten-year-old boy was blinded in one eye by powder and fragments of the cannon. (L-2217.)

WASHINGTON, D. C., JUNE 27, 1934. A seven-year-old boy was fatally burned when his clothing ignited following the explosion of a home-made fireworks "bomb" in the basement of his home. The victim and his brother had obtained the powder for the "bomb" from a large firecracker. Fireworks are illegal in this city. (L-2660.)

FAIRVIEW, ILL., JAN. 23, 1937. A man brought a keg of blasting powder into the house to dry beside a stove. The family were having their evening meal when the explosion wrecked the house and set it afire. The man and five of his children were killed. (L-3872.)

IX. Miscellaneous Explosions.

This section covers miscellaneous types of explosions in dwellings, most of which were responsible for only one or two explosions each. Examples of such causes are: explosion in motion picture machine due to a short circuit, gas from coal furnace was ignited by hot water heater, explosion while experimenting with insect powder, and explosion of a gas plant in a summer cottage. Also included are six explosions thought to be of incendiary origin and six explosions of unknown origin. Forty-two persons were killed and 29 were injured in these 32 miscellaneous explosions. Following are examples of this class.

WICHITA FALLS, TEXAS, DEC. 22, 1924. While making an effort to thaw out frozen water pipes with a gasoline blow torch, the torch exploded and seriously burned two boys. Little damage was done to the house, but one of the boys died. (H-22053.)

VANCOUVER, B. C., MAR. 29, 1925. A knife with a pyroxylin plastic handle had been used to prop open a defective damper on a hot air register from a gas-fired hot air furnace. This register was on a hot air pipe about ten feet long and with two elbows. The knife fell into the pipe and the damper closed. The knife handle decomposed, giving off a gas which pocketed in the pipe. This gas exploded, shooting flames and heavy black smoke across the room. Tests proved that there were no gas leaks from the furnace. The fire department extinguished the fire and the damage was small. (H-21910.)

TRENTON, N. J., JAN. 2, 1929. A man and his 23-year-old son were repairing the acetylene gas tank in the cellar of their home. The man's wife and their 21-year old daughter were in a bedroom on the second floor. The tank exploded and demolished the house. All were killed but the woman, who was badly injured as she was blown through a window. Firemen fought their way through the flames to recover the three bodies. (L-0416.)

WASHINGTON, PA., FEB. 10, 1933. Bodies of two men were found following an explosion and fire in a dwelling. The family was away at the time of the fire and the victims were unidentified. Four empty 5-gallon cans believed to have contained gasoline were found on the premises. It appears probable that incendiarism was the motive. (L-1930.)

HARTFORD, CONN., JUNE 28, 1934. A man who was interested in chemistry as a hobby was at work in his cellar laboratory. Suddenly a chemical became ignited and exploded. It is believed that he was stunned by the explosion, which knocked him to the floor and into the flames. He died from suffocation and burns. The house was badly damaged. (L-2708.)

Fires in Which There Was Loss of Life.

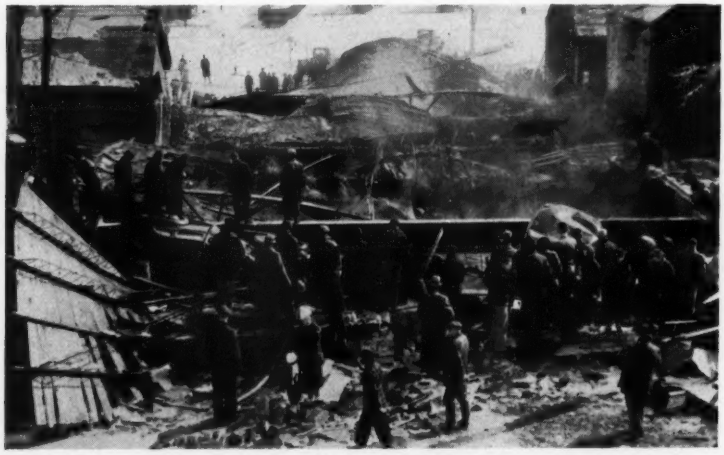
First Quarter, 1938.

Since the publication of the January QUARTERLY, the N.F.P.A. Department of Fire Record has received from various sources 199 reports of fires in which there was loss of life. A total of 376 lives were lost in these fires. During the period the following fires were reported in the United States and Canada, which caused the loss of five or more lives each.

DECEMBER 17, 1937, CHICAGO, ILL. In the assembly room of a match factory making book matches, sheets of paraffin-impregnated cardboard, tipped with match heads, were being cut up into small packets. Friction from the cutting machine ignited one of the matches. Almost immediately sheets of matches exploded. The employees in the room fled to the street with their clothing on fire. Five of them, all women, died from their burns. (H-42371.)

JANUARY 8, 1938, TRENTON, TENN. A kerosene explosion in a rural dwelling was fatal to one man, one woman and three children. (L-4071.)

JANUARY 12, 1938, PAGO PAGO, SAMOA. The Samoan Clipper, giant airplane of the Pan-American Airways transpacific service, exploded in midair and fell into the ocean. The crew of seven men were killed. It is believed that dumping of gasoline was responsible for the explosion. (H-42372.)



Acme.

In Bath, Maine, this explosion which wrecked a garage on March 1, 1938, was fatal to two men. Fumes in one of two empty tank trucks were thought to have been ignited. (H-42381.)

JANUARY 12, 1938, near PITTSBURGH, PA. An explosion in a coal mine was fatal to ten repairmen at work about two miles from the main entrance. Aside from repairs, the mine was idle at the time. (H-42373.)

JANUARY 16, 1938, FRANKLIN, N. J. Four children and their father were burned to death when their dwelling burned. They were found in their beds, indicating that they had first been overcome by smoke. (L-4072.)

JANUARY 18, 1938, ST. HYACINTHE, QUEBEC. Forty-one school children and five priests were trapped and burned to death when a Catholic school was destroyed by fire. (See account on page 275.)

JANUARY 22, 1938, KANSAS CITY, MO. A drunken taxicab driver turned his cab over while carrying four passengers. The fire that followed was fatal to them all. (H-42374.)

JANUARY 30, 1938, OXFORD, OHIO. Kerosene was used to start a fire in a dwelling. The explosion was fatal to a woman and four children. (L-4073.)

Loss of Life Fires, January-March, 1938.*

This is a typical rather than a complete record, presented to show the conditions under which loss of life occurs, that they may be known and guarded against. The total loss of life by fire in the United States is estimated at 10,000 annually.

Class of Fire	No. Fires	Men	Women	Children	Total
Airplanes	6	16	2	0	18
Amusement places	1	2	0	0	2
Apartments, hotels, tenements, etc.	26	19	14	5	38
Automobiles and trucks	4	7	1	0	8
Tank trucks	2	3	0	0	3
House trailers	1	0	0	2	2
Bakery	1	1	0	0	1
Clubs	2	5	0	0	5
Dry cleaning establishment	1	0	1	0	1
Dwellings—Rural	56	20	17	73	110
Dwellings—Urban	59	14	32	29	75
Forest or brush fires	2	2	0	0	2
Garages	2	3	0	0	3
Private garage	1	1	0	0	1
House boat	1	1	0	0	1
Institutions	1	1	0	0	1
Manufacturing occupancy, miscellaneous	6	13	0	0	13
Match factory	1	0	5	0	5
Mercantile occupancy, miscellaneous	4	4	0	0	4
Mining property	1	10	0	0	10
Office building	1	1	0	0	1
Oil refinery	1	2	0	0	2
Out of doors	7	2	2	3	7
Schools	2	6	0	41	47
Sheds and outbuildings	5	7	0	0	7
Tank vessels and barges	1	1	0	0	1
Warehouses	1	5	0	0	5
No data	3	1	0	2	3
Totals	199	147	74	155	376

*This table is made up from those reports received by the Department of Fire Record between January 1, 1938, and March 30, 1938. A few of the fires included herein occurred prior to January 1, but were not reported until subsequent to that date.

Causes of Loss of Life, January-March, 1938.

Fatalities classified according to the immediate cause of the loss of life rather than according to the cause of the fire.

Class of Fire	Men	Women	Children	Total
Airplane fires	16	2	0	18
Automobile and truck collisions and fires	6	1	0	7
Tank truck fires	3	0	0	3
Chemicals and explosives:				
Match factory explosion	0	5	0	5
Nitroglycerin	2	0	0	2
Powder factory explosion	1	0	0	1
Pyroxylin comb ignited	0	0	1	1
Children alone in house	0	0	44	44
Children playing with matches	0	0	7	7
Clothing ignited (see also flammable liquids on clothing):				
Bonfires, camp fires, rubbish fires	1	0	2	3
Burning paper in coal bucket	0	0	1	1
Electric heating pad in bed	0	1	0	1
Falling into fires	0	0	1	1
Filling oil lamp	0	1	0	1
Furnace, stove, heater (wood or coal)	2	11	3	16
Gas heater	0	1	0	1
Oil stove, heater or lamp	2	0	1	3
Smoking (see also smoking in bed)	3	2	0	5
Unknown cause	1	4	2	7
Escaping fires—jumped or fell	1	1	0	2
Explosions, miscellaneous:				
Divinylacetylene	3	0	0	3
Pulverized fuel	3	0	0	3
Fire fighting—civilians	0	1	0	1
Fire fighting—firemen	14	0	0	14
Flammable liquids and vapors:				
Alcohol explosion	1	0	0	1
"Empty" tanks exploded	3	0	0	3
Flammable liquids on clothing ignited	1	0	0	1
Gasoline barge fire	1	0	0	1
Heating flammable liquids other than gasoline	0	2	0	2
Home dry cleaning	0	1	0	1
Oil refinery fire	2	0	0	2
Oil stove explosion	1	4	2	7
Starting fires with gasoline	1	0	0	1
Starting fires with kerosene	0	10	6	16
Gasoline fires, not otherwise classified	3	0	0	3
Kerosene fires, not otherwise classified	3	1	3	7
Forest or brush fires (including fire fighting)	2	0	0	2
Indirect causes:				
Illness resulting from burns	2	1	1	4
Overexertion or shock at fires—civilians	1	1	0	2
Overexertion or shock at fires—firemen	1	0	0	1
Mine fires and explosions	10	0	0	10
Overcome by smoke—suffocation	2	1	0	3
Smoking in bed	4	2	0	6
Trapped in burning buildings	48	20	80	148
Trapped in Christmas tree fires	1	1	1	3
Trapped in incendiary fires	1	0	0	1
No data—burned	1	0	0	1
Totals	147	74	155	376

The type of automobile house trailer most often responsible for loss of life in fires is typified in this picture. Fire sweeps through such flimsy construction with almost unbelievable speed. In this fire three children were burned to death on the outskirts of Sterling, Colo., last November 9. (See January, 1938, Quarterly, page 260.)

MARCH 3, 1938, BUCKINGHAM COURTHOUSE, VA. Seven children were left alone in their two-room rural cabin. They were all burned to death in the fire that occurred soon afterwards. (L-4074.)

MARCH 9, 1938, LEATHERWOOD, VA. A man, his wife and five children were burned to death when they were trapped in a rural dwelling fire. (L-4075.)

MARCH 12, 1938, PATERSON, N. J. When a department store warehouse fire had been almost extinguished, firemen entered the ruins in search of possible victims. Five of them were killed when a brick wall collapsed. (H-42375.)

MARCH 13, 1938, BIG BANK, NOVA SCOTIA. A tiny frame dwelling in this rural community burned so rapidly that it was said to have been in complete ruins within five minutes. Five children were trapped and burned to death. A woman and her daughter who were sleeping near the door escaped. (L-4076.)

Foreign Fires.

Several outstanding loss of life fires outside the United States and Canada have been reported for this quarter. Foreign fires are not included in the tables. The most important are summarized here.

JANUARY 10, 1938, MADRID, SPAIN. Munitions stored in a railroad tunnel exploded just as a train discharged its passengers, and a reported 500 persons were killed.

JANUARY 29, 1938, SENGI, ITALY. An iron chisel used to open a clogged tube of compressed air in a munitions factory struck a spark and set off a powder explosion that killed 18 men.

FEBRUARY 10, 1938, MOSTAR, YUGOSLAVIA. During a wedding party in a dwelling the roof collapsed and burned. Thirty-six persons were crushed and burned to death.

FEBRUARY 22, 1938, EL RAHEBEIN, EGYPT. Twenty-three persons were trapped and burned to death by a conflagration that destroyed over 900 dwellings in four villages.

MARCH 13, 1938, HYDERBAD, INDIA. Forty-seven persons were killed by an explosion in the Singareni Coal Fields.

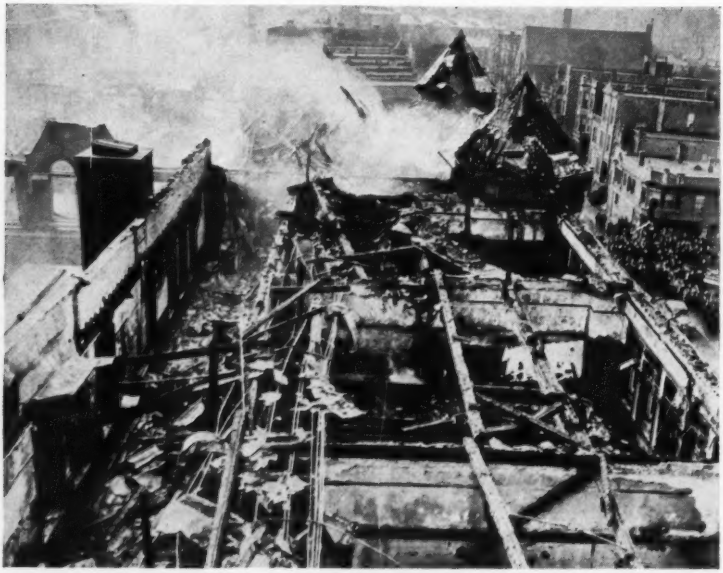
Typical Loss of Life Fires.

Automobile Trailer Fire.

JANUARY 2, 1938, ST. JOSEPH, MO. Two children, asleep in a home-made trailer, were burned to death when the kerosene stove exploded and set fire to the interior. (H-42376.)

Children Alone in House.

JANUARY 12, 1938, DENTVILLE, MD. A tenant house on a farm burned to the ground and took with it three small children. Their mother and father were both at work at the time. (L-4077.)



Acme.

Fighting the fire in this Chicago high school, one fireman was killed and another seriously injured. It occurred on Sunday, Feb. 6, when students were not in the building. (H-42382.)

JANUARY 22, 1938, SILVER CITY, N. M. Four children, alone in the house, were burned to death when a cat overturned an oil lamp and set their home on fire. (L-4078.)

FEBRUARY 1, 1938, WAVERLY, TENN. While their parents were in the barn adjoining their farmhouse, three small children were burned to death in a fire that swept through the house. (L-4079.)

Children Playing with Matches.

DECEMBER 31, 1937, COLUMBUS, OHIO. Two children were playing with kerosene and matches. One of them threw some of the liquid on the other's clothing. The other applied a match to see if it would burn. He was burned to death. (L-4080.)

Clothing Ignited.

DECEMBER 5, 1937, PARSONS, KANS. A woman who was known to be a heavy smoker was found with her clothing burned off near a charred couch in her home. Firemen believed she had set fire to her clothing while smoking on the couch. (L-4082.)

DECEMBER 11, 1937, ST. JOSEPH, MO. A man fell asleep while smoking in his home. The burns he received when his clothing caught fire were not thought to be serious, but 17 days later he died from their effect. (L-4083.)

JANUARY 5, 1938, EVANSVILLE, IND. A young boy was burned to death when he stood too close to a coal bucket in which some paper was burning, and the flames set fire to his clothing. He ran from the house and thus fanned the fire over his entire body. (L-4081.)

JANUARY 19, 1938, OCEANSIDE, L. I. A woman set fire to her clothing when she fell asleep while smoking in the living room of her home. She ran from the house with her clothing burning furiously and rolled in the snow. Her burns, however, were fatal. (L-4084.)

Christmas Tree Fire.

JANUARY 4, 1938, NEW YORK, N. Y. A short circuit in the wiring of Christmas tree lights started a fire in a New York apartment building that trapped the occupants of the apartment above and suffocated one man there before firemen could effect a rescue. (H-42377.)

Electric Heating Pad Ignited Bedding.

JUNE 22, 1935, SAN FRANCISCO, CAL. Escaping the attention of the Department of Fire Record until recently, a fire is now reported in which a woman awakened in the night to find that her bed clothing had been ignited by an overheated warming pad. She was able to reach a telephone and call for help, but it was too late to save her life. (L-4085.)

"Empty" Tanks Exploded.

MARCH 3, 1938, RICHMOND, VA. Two men drained the gasoline tank of

These ruins were all that were left after a fire in a small Los Duranes, New Mexico, adobe home had burned to death two children who had been left alone. The fire occurred on February 3, 1938. (L-4096.)

an automobile preparatory to applying a welding torch. The tank exploded as soon as the heat was applied, however, and one of the men was killed; the other was seriously burned. (H-42378.)

Fire Fighting, Firemen.

JANUARY 6, 1938, KANSAS CITY, MO. A fireman was fighting a fire in a drug store. Seeking a fire extinguisher, he was overcome by smoke in the basement. He was not found for several hours and was then dead. (H-42379.)

FEBRUARY 20, 1938, NASHVILLE, TENN. Several firemen entered the ruins of a smouldering factory building with hose lines to finish the job of extinguishment. A wall collapsed and crushed to death three of them. Five others, who were dug from the ruins, survived. (H-42380.)

MARCH 6, 1938, ELIZABETH, N. J. Fighting a fire in an urban dwelling, three firemen were working on a porch as the fire neared extinguishment. Suddenly the roof collapsed about their heads. One was killed and the other two were seriously injured. (L-4086.)

Fire Fighting, Civilians.

JANUARY 13, 1938, NEVADA, MO. A woman tried to put out a fire in a shock of fodder at her farmhouse, and was burned to death after her clothing ignited. (L-4087.)

Heating Flammable Liquids.

OCTOBER 14, 1937, RENSSELAER, IND. A woman was burned to death when tar which she was boiling on her kitchen stove exploded. The fire destroyed her farm dwelling. There was no water with which the firemen could fight it. (L 4088.)

DECEMBER 9, 1937, MUSCOTAH, KANSAS. A woman was heating some oil on the stove at her farmhouse. When it ignited, she attempted to carry it out

of the house. A screen door struck the container and spilled the flaming oil on her clothing. She dropped the can and ran to the pump, where, with the aid of a young son, she poured water on and extinguished the fire in her clothing. Several days later, however, her burns proved fatal. (L-4089.)

Pyroxylin Comb Ignited.

JANUARY 26, 1938, AUGUSTA, MAINE. A child was playing with a pyroxylin comb near a stove in his home. Suddenly the comb flashed into flame, igniting in turn his clothing and causing his death. (L-4090.)

Illness Following Burns.

JULY 18, 1937, OVERLAND, MO. A boy who was playing around a trash fire poured on some gasoline and set fire to his clothing. While his burns were healing he contracted pneumonia and a heart ailment, which were fatal on January 21, 1938. (L-4091.)

JANUARY 7, 1938, ST. LOUIS, MO. A woman set fire to her night clothing as she was lighting some incense. The flames were extinguished in time to save her life, but, in the hospital, pneumonia developed as a result of the burns, and she died on January 25. (L-4092.)

Overexertion at Fires.

JANUARY 25, 1938, PETERSBURG, VA. While fighting a fire in his chimney, a 65-year-old farmer was stricken with a heart attack and died. (L-4093.)

Oil Stove Explosion.

FEBRUARY 2, 1938, FRANCONIA, VA. An explosion of a makeshift oil stove constructed by a plumber's helper was fatal to him and destroyed his isolated home. (L-4094.)

Smoking in Bed.

DECEMBER 10, 1937, KANSAS CITY, MO. A woman dropped the cigarette she was smoking in bed and it ignited her bed covering. She suffered burns that soon caused her death. (L-4095.)

Annual Sprinkler Tables—1938.

The annual sprinkler tabulation is published this year for the forty-second consecutive year. The tables which follow show the actual fire experience with automatic sprinkler equipments in seventy-five thousand four hundred fires. This is not intended as a complete statistical report of fires in sprinklered properties; it includes only those fires reported to the N.F.P.A. Department of Fire Record in sufficient detail to give the data necessary for the tables. In 13,992 of them sprinklers were not a factor.

The total number of sprinklered fire reports received during the past year was 1700, including 73 fires in which the sprinklers were not a factor. Fires that occurred in unsprinklered portions of buildings and did not extend to the sprinklered portions, or fires that occurred in sprinklered portions and were discovered and extinguished by other means before there was sufficient heat to open sprinklers are included in the latter figure.

The classifications "extinguished fire" and "held fire in check" appearing in the several tables may both be considered as satisfactory performance. The distinction between these two classifications is necessarily more or less arbitrary, depending upon the judgment of the original inspector. The great majority of the fires in the "held in check" columns are instances where hose streams or other equipment were used to extinguish fire in spaces which water from the sprinklers did not reach because of minor obstructions to distribution or unsprinklered portions, but where sprinklers functioned satisfactorily in preventing the spread of fire.

When reviewing the detailed tabulation of unsatisfactory sprinkler performance it should be noted that these fires represent a small percentage of the total number included in the record and that they are compiled not with the thought of emphasizing the relatively few cases where sprinkler operation is unsatisfactory, but pointing the way toward better performance by indicating those factors which should receive attention.

The annual sprinkler tables are designed to show to what degree fires have been automatically controlled in buildings equipped with automatic sprinklers. The term "Unsatisfactory" does not necessarily imply mechanical failure of the sprinkler equipment. Neither does it indicate that there was a large loss in a sprinklered building. "Unsatisfactory" sprinkler control means that for various reasons the sprinkler equipment did not automatically extinguish the fire or hold it in check. Reasons for "Unsatisfactory" sprinkler control are shown in Section I, and in Table No. 5 of Section II, of the following tables. In many of the fires where automatic sprinkler control was "Unsatisfactory" the loss was small, due to prompt extinguishment by other fire fighting equipment.

Large Loss Fires Due to Unsatisfactory Sprinkler Operation.

Each year several cases of sprinkler failure where the fire resulted in large loss are included in these tables. Believing these to be of sufficient interest to warrant some additional attention, the Department of Fire Record inaugurates this year a new feature in the annual tabulation of sprinklered fires. This section will include a brief description of the failure of sprinkler protection in all those fires where the loss is known to be $100,000 or over. Reports received during the past year included eight such fires. They are individually summarized below.

FEBRUARY 3, 1937: Following the flood at Cincinnati, Ohio, a large furniture factory was ignited from an unknown cause. The sprinkler equipment had been damaged during the flood, and the gravity tank water supply had drained through the broken piping. The city water mains were shut off in the area. City fire alarm boxes were out of order. After a delayed alarm the fire department fought the fire with pumpers, using flood waters from basements. The loss to the factory was $100,000. (See page 354, April, 1937, QUARTERLY.)

FEBRUARY 17, 1937: In a cotton warehouse in Carrollton, Ga., a fire that started low in piled bales suddenly flashed out and opened many sprinkler heads. These overtaxed the limited water supply, and when several fire department hose lines were put into operation the supply to the system was further depleted. The fire was finally extinguished with a loss of $225,000.

APRIL 9, 1937: In a drug factory at Detroit, Michigan, an explosion of chemicals was fatal to three employees. Sprinklers opened, but uselessly, as no fire followed the explosion. The loss was $100,000.

JUNE 15, 1937: Sprinklers in a patent leather factory at Mansfield, Mass., were shut off after a small fire had been extinguished by two heads. Shortly afterwards an explosion occurred and fire involved the whole plant. Sprinklers were not turned on again until the fire was out of control. The loss was $173,000.

JUNE 29, 1937: A dip tank of a plant manufacturing farm implements in Canton, Ill., was ignited by a static spark. The overflow pipe of the tank was small and at this time happened to be clogged. The tank overflowed on to the floor, spreading the fire too quickly to be controlled by the sprinkler system. The damage amounted to over $200,000.

AUGUST 27, 1937: In a cooperage plant at Little Rock, Ark., a fire that started on the first floor worked down through to the underside and spread unimpeded by sprinklers through an under-floor area three feet in height. When it broke through again it was out of control and sprinklers which opened were powerless to extinguish or hold it in check. The loss was $113,000.

AUGUST 29, 1937: When a watchman heard the sprinkler alarm operating in a foundry in Cambridge, Mass., his first action was to shut the sprinkler

valve. Investigation finally uncovered the fire, but by the time sprinklers were operating again the fire was out of control and was not extinguished by the fire department and sprinklers combined until $150,000 loss had been suffered.

JANUARY 9, 1938: When a fire was discovered in a grocery warehouse in Hamilton, Ohio, sprinklers which had been shut off for some time were turned on in one small section. These checked the fire at that point. The caretaker stated that he had not turned on other sprinklers because he thought the system was full of mud. The loss was $200,000.

SECTION I.

Summary of Unsatisfactory Sprinkler Fires.

	1937-1938 No. of Fires	1937-1938 Per Cent	1897-1938 No. of Fires	1897-1938 Per Cent
Water shut off	29	51.8	803	33.5
Generally defective equipment	4	7.1	214	8.9
Unsprinklered portions	1	1.8	192	8.0
Defective water supply or supplies	4	7.1	209	8.7
Slow operation of dry system or defective valve	1	1.8	75	3.1
Sprinkler system crippled due to freezing	..	...	70	2.9
Slow or defective operation of high test heads	..	...	27	1.1
Obstruction to distribution	1	1.8	141	5.9
Faulty building construction, concealed spaces, vertical openings, etc.	3	5.4	117	4.9
Hazard of occupancy too severe for average sprinkler equipment	4	7.1	138	5.8
Explosion crippled sprinkler system	2	3.6	116	4.8
Exposure or conflagration	1	1.8	91	3.8
Plugged heads and clogged piping	5	8.9	75	3.2
Miscellaneous	1	1.8	130	5.4
Total	56	100.0	2398	100.0

Fires in Which Failure Was Due to Water Shut Off Sprinklers.

Water shut off:	1937-1938 No. of Fires	1897-1938 No. of Fires
Unknown reason, neglect or carelessness	7	237
Before fire was out, or fire rekindled	11	156
Accidents or repairs	6	120
To prevent freezing	5	180
Probably incendiary	..	36
Leaky dry system	..	21
Defective gate valve	..	9
Miscellaneous	..	44
Total	29	803

SECTION II.

Table No. 1 — Effect of Sprinklers.

	1937-1938 No. of Fires	%	1897-1938 No. of Fires	%
Practically or entirely extinguished....	1143	70.3	43025	70.1
Held fire in check.....	428	26.3	15985	26.0
Total Satisfactory.....	1571	96.6	59010	96.1
Unsatisfactory	56	3.4	2398	3.9
Total	1627	100.0	61408	100.0

Table No. 2 — Number of Sprinklers Operating—Cumulative.

No. of Fires, 1897-1938.

No. of Sprinklers Operating	Wet	%	Dry	%	No Data	Total	%
1 18629		39.1	2116	20.4	780	21525	35.0
2 or less.....27490		57.7	3611	34.8	1139	32240	52.4
3 or less.....32172		67.5	4520	43.6	1342	38034	61.8
4 or less.....35361		74.2	5271	50.9	1510	42142	68.5
5 or less.....37295		78.3	5766	55.7	1613	44674	72.6
6 or less.....38821		81.5	6201	59.9	1703	46725	75.9
7 or less.....39905		83.8	6547	63.2	1751	48203	78.3
8 or less.....40906		85.9	6839	66.0	1815	49560	80.5
9 or less.....41568		87.3	7082	68.3	1855	50505	82.0
10 or less.....42155		88.5	7282	70.2	1904	51341	83.4
11 or less.....42617		89.5	7447	71.8	1927	51991	84.5
12 or less.....43107		90.5	7662	73.9	1979	52748	85.7
13 or less.....43398		91.1	7814	75.4	1998	53210	86.5
14 or less.....43728		91.8	7971	76.9	2027	53726	87.3
15 or less.....43998		92.4	8099	78.1	2049	54146	88.0
20 or less.....44935		94.4	8530	82.3	2129	55594	90.4
25 or less.....45489		95.6	8837	85.3	2169	56495	91.9
30 or less.....45862		96.4	9048	87.3	2200	57110	92.9
35 or less.....46095		96.9	9199	88.8	2225	57519	93.6
40 or less.....46299		97.3	9318	89.9	2248	57865	94.2
50 or less.....46552		97.8	9490	91.6	2281	58323	94.9
75 or less.....46894		98.5	9712	93.7	2316	58922	95.9
100 or less.....47050		98.8	9830	94.8	2329	59209	96.4
Over 100.....	471		396		56	923	
No data.....	119		110		1014	1243	
Open head systems.	0		33		0	33	
Total.....47640			10369		3399	61408	

Table No. 3 — Number of Sprinklers Operating.

No. of Fires, 1937-1938.

No. of Sprinklers Operating	Wet	%	Dry	%	No Data	Total	%
1	558	44.9	61	19.3	14	633	39.0
2	229	18.4	51	16.1	5	285	17.5
3	105	8.5	29	9.1	3	137	8.4
4	69	5.6	25	7.9	7	101	6.2
5	62	5.0	18	5.7	1	81	5.0
6	24	1.9	4	1.3	1	29	1.8
7	30	2.4	13	4.1	0	43	2.6
8	25	2.0	9	2.8	3	37	2.3
9	12	1.0	7	2.2	0	19	1.2
10	11	.9	10	3.2	1	22	1.4
11	16	1.3	4	1.3	1	21	1.3
12	9	.7	12	3.8	3	24	1.5
13	10	.8	4	1.3	0	14	.8
14	10	.8	10	3.2	3	23	1.4
15	7	.6	3	.9	0	10	.6
16-20	19	1.5	10	3.2	2	31	1.9
21-25	12	1.0	5	1.6	1	18	1.1
26-30	3	.2	7	2.2	2	12	.7
31-35	7	.6	4	1.3	2	13	.8
36-40	1	.1	1	.3	2	4	.2
41-50	4	.3	5	1.6	0	9	.6
51-75	6	.5	5	1.6	1	12	.7
76-100	4	.3	4	1.3	2	10	.6
Over 100	4	.3	9	2.8	3	16	1.0
No data	5	.4	5	1.6	12	22	1.3
Open head systems	0	..	1	.3	0	1	.1
Total	1242	100.0	316	100.0	69	1627	100.0

No. of Fires, 1897-1938.

No. of Sprinklers Operating	Wet	%	Dry	%	No Data	Total	%
1	18629	39.1	2116	20.4	780	21525	35.0
2	8861	18.6	1495	14.4	359	10715	17.4
3	4682	9.8	909	8.8	203	5794	9.4
4	3189	6.7	751	7.3	168	4108	6.7
5	1934	4.1	495	4.8	103	2532	4.1
6	1526	3.2	435	4.2	90	2051	3.3
7	1084	2.3	346	3.3	48	1478	2.4
8	1001	2.1	292	2.8	64	1357	2.2
9	662	1.4	243	2.3	40	945	1.5
10	587	1.2	200	1.9	49	836	1.4
11	462	1.0	165	1.6	23	650	1.1
12	490	1.0	215	2.1	52	757	1.2
13	291	.6	152	1.5	19	462	.8
14	330	.7	157	1.5	29	516	.8
15	270	.6	128	1.2	22	420	.7
16-20	937	2.0	431	4.2	80	1448	2.4
21-25	554	1.2	307	3.0	40	901	1.5
26-30	373	.8	211	2.0	31	615	1.0
31-35	233	.5	151	1.5	25	409	.7
36-40	204	.4	119	1.1	23	346	.6
41-50	253	.5	172	1.7	33	458	.7
51-75	342	.7	222	2.1	35	599	1.0
76-100	156	.3	118	1.1	13	287	.5
Over 100	471	1.0	396	3.8	56	923	1.5
No data	119	.2	110	1.1	1014	1243	2.0
Open head systems	0	..	33	.3	0	33	.1
Total	47640	100.0	10369	100.0	3399	61408	100.0

Table No. 4 — Effect of Sprinklers by Class of Occupancy.

	Extinguished Fire		Held Fire in Check		Total Satisfactory		Unsatisfactory		Total No. of Fires
	No.	%	No.	%	No.	%	No.	%	
Abrasive Works	31	73.8	9	21.4	40	95.2	2	4.8	42
Agricultural Implements	88	62.0	48	33.8	136	95.8	6	4.2	142
Airplane Factories	9	53.0	8	47.0	17	100.0	0	0.0	17
Airports and Hangars	3	50.0	3	50.0	6	100.0	0	0.0	6
Alcohol Distilleries	1	16.7	4	66.6	5	83.3	1	16.7	6
Aluminum Works	7	50.0	5	35.7	12	85.7	2	14.3	14
Amusement Places	39	78.0	6	12.0	45	90.0	5	10.0	50
Apartment Houses	201	87.0	30	13.0	231	100.0	0	0.0	231
Artificial Leather Mfg	41	53.3	33	42.8	74	96.1	3	3.9	77
Asbestos Works	30	56.6	20	37.7	50	94.3	3	5.7	53
Automobile Mfg	377	66.3	167	29.3	544	95.6	25	4.4	569
Automobile Body Mfg	167	59.7	87	31.0	254	90.7	26	9.3	280
Automobile Paint Shops	14	60.9	9	39.1	23	100.0	0	0.0	23
Auto Sales and Service	71	71.0	23	23.0	94	94.0	6	6.0	100
Bag Factories	57	60.6	31	33.0	88	93.6	6	6.4	94
Bakeries	233	77.2	61	20.2	294	97.4	8	2.6	302
Basket Factories	15	83.2	2	11.2	17	94.4	1	5.6	18
Battery Mfg	48	67.6	20	28.2	68	95.8	3	4.2	71
Bolt, Nut, and Screw Works	27	60.0	15	33.3	42	93.3	3	6.7	45
Bottle Cap and Seals Mfg	57	58.2	41	41.8	98	100.0	0	0.0	98
Bottling Works	12	75.0	3	18.8	15	93.8	1	6.2	16
Braid Mills	74	76.3	21	21.6	95	97.9	2	2.1	97
Brass and Copper Works	91	73.4	30	24.2	121	97.6	3	2.4	124
Breweries	5	55.5	4	44.5	9	100.0	0	0.0	9
Brick and Tile Works	1	100.0	0	0.0	1	100.0	0	0.0	1
Broom Factories	29	72.5	8	20.0	37	92.5	3	7.5	40
Brush Factories	38	70.3	15	27.8	53	98.1	1	1.9	54
Buildings Under Construction	5	50.0	3	30.0	8	80.0	2	20.0	10
Button Factories	86	83.5	15	14.6	101	98.1	2	1.9	103
Candle Factories	10	58.8	7	41.2	17	100.0	0	0.0	17
Candy Factories	283	72.8	95	24.4	378	97.2	11	2.8	389
Canneries	20	62.5	9	28.1	29	90.6	3	9.4	32
Canvas and Cotton Belting	9	69.2	4	30.8	13	100.0	0	0.0	13
Carbon Works	12	80.0	3	20.0	15	100.0	0	0.0	15
Car Houses	48	46.5	46	44.7	94	91.2	9	8.8	103
Car Works	83	61.0	49	36.1	132	97.1	4	2.9	136
Carpet and Rug Mills	239	65.4	112	30.7	351	96.1	14	3.9	365
Casket Mfg	92	75.4	25	20.5	117	95.9	5	4.1	122
Cement and Plaster Mills	16	72.8	3	13.6	19	86.4	3	13.6	22
Cereal Mills	46	63.9	18	25.0	64	88.9	8	11.1	72
Chemical and White Lead Works	261	62.9	128	30.8	389	93.7	26	6.3	415
Churches	1	100.0	0	0.0	1	100.0	0	0.0	1
Clock and Watch Mfg	22	81.5	5	18.5	27	100.0	0	0.0	27
Clothing Mfg	2566	85.9	397	13.3	2963	99.2	25	0.8	2988
Clubs—City	38	84.5	6	13.3	44	97.8	1	2.2	45
Clubs—Country	25	67.6	11	29.7	36	97.3	1	2.7	37
Coal and Wood Yards	3	27.3	7	63.6	10	90.9	1	9.1	11
Cocoanut Mills	6	75.0	2	25.0	8	100.0	0	0.0	8
Coffee and Spice Plants	111	72.1	40	26.0	151	98.1	3	1.9	154
Cold Storage Plants	20	71.4	8	28.6	28	100.0	0	0.0	28
Cooperage Plants	67	59.3	32	28.3	99	87.6	14	12.4	113
Cordage Works	274	65.4	129	30.8	403	96.2	16	3.8	419
Cork Plants	44	60.3	23	31.5	67	91.8	6	8.2	73
Cotton Gins	14	60.9	7	30.4	21	91.3	2	8.7	23
Cotton Mills	7020	65.9	3521	33.0	10541	98.9	122	1.1	10663
Cotton Seed Oil Mills	49	47.2	35	33.6	84	80.8	20	19.2	104
Cotton Warehouses	284	50.5	227	40.4	511	90.9	51	9.1	562

	Extinguished Fire		Held Fire in Check		Total Satisfactory		Unsatisfactory		Total No. of Fires
	No.	%	No.	%	No.	%	No.	%	
Cutlery Mfg.	31	60.8	17	33.3	48	94.1	3	5.9	51
Dairies and Creameries	12	70.6	5	29.4	17	100.0	0	0.0	17
Department Stores	948	80.6	204	17.3	1152	97.9	25	2.1	1177
Distilleries	17	60.7	6	21.4	23	82.1	5	17.9	28
Doll Factories	101	66.0	52	34.0	153	100.0	0	0.0	153
Drug Mfg. and Warehouse	293	80.9	65	17.7	358	97.6	9	2.4	367
Dry Cleaning Establishments	37	68.5	15	27.8	52	96.3	2	3.7	54
Dry Goods Stores	433	86.4	62	12.4	495	98.8	6	1.2	501
Dwellings	2	66.7	0	0.0	2	66.7	1	33.3	3
Dyeing, Bleaching, Finishing	362	61.2	211	35.6	573	96.8	19	3.2	592
Electrical Appliance Mfg.	625	74.0	205	24.3	830	98.3	14	1.7	844
Electric Power and Light	10	43.5	9	39.1	19	82.6	4	17.4	23
Excelsior Factories	39	68.4	13	22.8	52	91.2	5	8.8	57
Fertilizer Plants	33	66.0	13	26.0	46	92.0	4	8.0	50
Fibre Products	21	52.5	14	35.0	35	87.5	5	12.5	40
Fireworks Plants	2	28.6	3	42.8	5	71.4	2	28.6	7
Flax and Linen Mills	54	58.7	37	40.2	91	98.9	1	1.1	92
Flour and Grist Mills	108	56.0	53	27.4	161	83.4	32	16.6	193
Forge and Smithy	31	70.5	11	25.0	42	95.5	2	4.5	44
Foundries	273	60.3	157	34.8	430	95.1	22	4.9	452
Fruit Packing	11	84.6	2	15.4	13	100.0	0	0.0	13
Fur Works	289	92.3	18	5.8	307	98.1	6	1.9	313
Furniture Factories	1211	68.8	427	24.2	1638	93.0	123	7.0	1761
Furniture Stores	166	79.8	34	16.4	200	96.2	8	3.8	208
Garages	736	72.3	261	25.6	997	97.9	21	2.1	1018
Garbage Reduction Plants	3	50.0	2	33.3	5	83.3	1	16.7	6
Gas Works	4	44.4	4	44.5	8	88.9	1	11.1	9
General Stores	1	50.0	1	50.0	2	100.0	0	0.0	2
Glass Factories	122	61.0	59	29.5	181	90.5	19	9.5	200
Glove Factories	23	67.7	10	29.4	33	97.1	1	2.9	34
Glue Factories	11	47.9	9	39.1	20	87.0	3	13.0	23
Grain Elevators	49	43.4	36	32.5	85	75.9	27	24.1	112
Groceries	257	79.1	56	17.2	313	96.3	12	3.7	325
Gum Mfg.	11	84.6	2	15.4	13	100.0	0	0.0	13
Hair Works	33	78.6	9	21.4	42	100.0	0	0.0	42
Hardware Stores	143	81.3	30	17.0	173	98.3	3	1.7	176
Hat Factories	522	80.9	102	15.8	624	96.7	21	3.3	645
Hospitals	41	82.0	9	18.0	50	100.0	0	0.0	50
Hotels—Year Round	149	83.2	25	14.0	174	97.2	5	2.8	179
Hotels—Seasonal	23	71.9	8	25.0	31	96.9	1	3.1	32
Ice Cream Mfg.	7	58.3	5	41.7	12	100.0	0	0.0	12
Ice Houses	0	0.0	2	66.7	2	66.7	1	33.3	3
Ice Mfg.	2	66.7	1	33.3	3	100.0	0	0.0	3
Idle and Vacant Property	56	54.9	22	21.6	78	76.5	24	23.5	102
Incandescent Lamp Works	27	67.5	13	32.5	40	100.0	0	0.0	40
Institutions	23	95.8	1	4.2	24	100.0	0	0.0	24
Insulated Wire Works	73	67.0	34	31.2	107	98.2	2	1.8	109
Jewelry Factories	226	82.7	39	14.4	265	97.1	8	2.9	273
Junk Shops	39	63.9	17	27.9	56	91.8	5	8.2	61
Knitting Mills—Cop Yarn	79	69.3	28	24.6	107	93.9	7	6.1	114
Knitting Mills—Full Process	726	69.6	284	27.2	1010	96.8	33	3.2	1043
Lamp Shade Factories	62	89.8	6	8.7	68	98.5	1	1.5	69
Laundries	220	74.4	67	22.6	287	97.0	9	3.0	296
Leather Working	292	83.5	53	15.1	345	98.6	5	1.4	350
Linoleum Works	44	30.4	81	55.8	125	86.2	20	13.8	145
Linseed Oil Works	29	51.7	18	32.2	47	83.9	9	16.1	56
Lumber Yards	10	55.5	7	38.9	17	94.4	1	5.6	18
Macaroni Factories	14	60.9	7	30.4	21	91.3	2	8.7	23
Machine Shops and Works	539	72.8	168	22.7	707	95.4	33	4.5	740

	Extinguished Fire		Held Fire in Check		Total Satisfactory		Unsatisfactory		Total No. of Fires
	No.	%	No.	%	No.	%	No.	%	
Mail Order Houses	69	86.3	11	13.7	80	100.0	0	0.0	80
Match Factories	81	75.0	22	20.4	103	95.4	5	4.6	108
Mattress Factories	747	71.9	275	26.4	1022	98.3	18	1.7	1040
Mercantile (Miscellaneous)	1227	83.2	213	14.4	1440	97.6	35	2.4	1475
Metal Reduction Plants	11	61.1	7	38.9	18	100.0	0	0.0	18
Metal Workers†	1468	65.1	706	31.3	2174	96.4	82	3.6	2256
Mining Property	7	70.0	2	20.0	9	90.0	1	10.0	10
Mirror Mfg.	22	88.0	2	8.0	24	96.0	1	4.0	25
Miscellaneous	500	75.1	146	22.0	646	97.1	19	2.9	665
Motion Picture Exchanges	58	78.4	14	18.9	72	97.3	2	2.7	74
Motion Picture Studios	63	76.8	18	22.0	81	98.8	1	1.2	82
Motion Picture Theatres	117	79.0	25	16.9	142	95.9	6	4.1	148
Multiple Occupancy	235	78.9	46	15.4	281	94.3	17	5.7	298
Munitions	27	44.3	24	39.3	51	83.6	10	16.4	61
Musical Instrument Factories	174	71.0	64	26.1	238	97.1	7	2.9	245
Office Buildings	147	89.6	16	9.8	163	99.4	1	.6	164
Oil Cloth Works	39	51.3	30	39.5	69	90.8	7	9.2	76
Oil Clothing Factories	26	86.7	3	10.0	29	96.7	1	3.3	30
Oil Distributing Stations	2	40.0	3	60.0	5	100.0	0	0.0	5
Oil Refineries—Animal	5	55.6	3	33.3	8	88.9	1	11.1	9
Oil Refineries—Mineral	7	58.4	4	33.3	11	91.7	1	8.3	12
Oil Refineries—Vegetable	13	48.2	12	44.4	25	92.6	2	7.4	27
Optical Works	28	68.3	13	31.7	41	100.0	0	0.0	41
Packing Houses	220	67.9	89	27.5	309	95.4	15	4.6	324
Paint and Varnish Works	353	65.7	163	30.4	516	96.1	21	3.9	537
Paper Coating Mills	51	67.1	19	25.0	70	92.1	6	7.9	76
Paper Mills	776	52.6	569	38.6	1345	91.2	130	8.8	1475
Paper Working	489	74.7	152	23.2	641	97.9	14	2.1	655
Peanut Roasting Plants	7	53.8	3	23.1	10	76.9	3	23.1	13
Pencil Factories	22	71.0	8	25.8	30	96.8	1	3.2	31
Phonograph Works	36	67.9	15	28.3	51	96.2	2	3.8	53
Photo Camera and Film Mfg.	30	73.2	11	26.8	41	100.0	0	0.0	41
Photo Engraving and Studios	72	88.9	8	9.9	80	98.8	1	1.2	81
Picture Frame Mfg.	69	68.3	26	25.8	95	94.1	6	5.9	101
Piers and Wharves	31	55.3	22	39.3	53	94.6	3	5.4	56
Plumbers Supplies	48	75.0	13	20.3	61	95.3	3	4.7	64
Potteries	62	64.6	26	27.1	88	91.7	8	8.3	96
Printing and Lithographing	1390	83.2	253	15.1	1643	98.3	28	1.7	1671
Prisons	6	46.2	5	38.4	11	84.6	2	15.4	13
Public Buildings	14	73.7	3	15.8	17	89.5	2	10.5	19
Pulp Mills	54	39.5	56	40.8	110	80.3	27	19.7	137
Pyroxylin Plastic Mfg., Fabrication	306	66.2	111	24.0	417	90.2	45	9.8	462
Radios and Accessories	80	81.6	15	15.3	95	96.9	3	3.1	98
Railroad—Misc. Property	5	29.4	11	64.7	16	94.1	1	5.9	17
Railroad—Repair Shops	4	36.4	7	63.6	11	100.0	0	0.0	11
Rayon Mills	34	81.0	6	14.2	40	95.2	2	4.8	42
Restaurants	267	76.9	77	22.2	344	99.1	3	.9	347
Rice Mills	2	25.0	2	25.0	4	50.0	4	50.0	8
Rolling, Wire and Tube Mills	97	62.6	52	33.5	149	96.1	6	3.9	155
Roofing Works	55	37.4	81	55.1	136	92.5	11	7.5	147
Rooming and Lodging Houses	10	90.9	0	0.0	10	90.9	1	9.1	11
Rubber Cloth Factories	112	68.3	48	29.3	160	97.6	4	2.4	164
Rubber Reclaiming Works	23	46.0	10	27.0	33	73.0	10	27.0	43
Rubber Mills	338	58.2	215	37.0	553	95.2	28	4.8	581
Salt Works	2	50.0	2	50.0	4	100.0	0	0.0	4
Saw and Planing Mills	132	42.2	98	31.3	230	73.5	83	26.5	313
Schools—Colleges and Universities	23	82.1	5	17.9	28	100.0	0	0.0	28
Schools—Private	8	66.7	3	25.0	11	91.7	1	8.3	12
Schools—Public	9	56.2	4	25.0	13	81.2	3	18.8	16

	Extinguished Fire		Held Fire in Check		Total Satisfactory		Unsatisfactory		Total No. of Fires
	No.	%	No.	%	No.	%	No.	%	
Schools—Trade and Industrial	15	79.0	2	10.5	17	89.5	2	10.5	19
Shipyards	20	52.6	15	39.5	35	92.1	3	7.9	38
Shoddy Mills	298	63.5	144	30.8	442	94.3	26	5.7	468
Shoe Factories	1132	76.0	307	20.6	1439	96.6	51	3.4	1490
Shoe Mfg. Accessories	115	71.0	40	24.7	155	95.7	7	4.3	162
Shoe Stores	98	88.3	13	11.7	111	100.0	0	0.0	111
Silk Mills	219	82.6	38	14.4	257	97.0	8	3.0	265
Smelting and Refining	8	61.5	4	30.8	12	92.3	1	7.7	13
Soap Mfg.	60	70.6	22	25.9	82	96.5	3	3.5	85
Stables	25	75.8	8	24.2	33	100.0	0	0.0	33
Stamping and Sheet Metal Works	212	63.8	102	30.8	314	94.6	18	5.4	332
Starch and Glucose	17	54.8	6	19.4	23	74.2	8	25.8	31
Stone Working	4	100.0	0	0.0	4	100.0	0	0.0	4
Sugar Refineries	45	51.7	38	43.7	83	95.4	4	4.6	87
Tannery, Class A**	29	46.0	29	46.0	58	92.0	5	8.0	63
Tannery, Class B**	156	59.3	86	32.7	242	92.0	21	8.0	263
Tannery, Class C**	19	41.3	21	45.7	40	87.0	6	13.0	46
Tannery, Class D**	30	69.8	11	25.6	41	95.4	2	4.8	43
Telephone Exchanges	4	100.0	0	0.0	4	100.0	0	0.0	4
Tenant Mfg.	2266	79.3	489	17.1	2755	96.4	102	3.6	2857
Theatres	109	76.8	25	17.6	134	94.4	8	5.6	142
Tobacco Factories	101	75.9	28	21.1	129	97.0	4	3.0	133
Tobacco Warehouses	10	66.7	4	26.6	14	93.3	1	6.7	15
Trunk Factories	51	74.0	11	15.9	62	89.9	7	10.1	69
Umbrella Mfg.	23	81.6	4	14.8	27	96.4	1	3.6	28
Vinegar Works	2	100.0	0	0.0	2	100.0	0	0.0	2
Wall Paper Factories	31	72.1	8	18.6	39	90.7	4	9.3	43
Warehouses	591	74.5	163	20.6	754	95.1	39	4.9	793
Waste and Batting Mills	444	61.0	251	34.6	695	95.6	32	4.4	727
Waste Paper and Rag Shops	338	65.6	153	29.7	491	95.3	24	4.7	515
Water Works	1	33.3	2	66.7	3	100.0	0	0.0	3
Weaving Mills	226	70.0	90	27.8	316	97.8	7	2.2	323
Window Shade Factories	20	76.9	4	15.4	24	92.3	2	7.7	26
Woodworker, Class A*	229	54.9	132	31.5	361	86.4	57	13.6	418
Woodworker, Class B*	226	54.1	154	36.8	380	90.9	38	9.1	418
Woodworker, Class C*	240	62.0	125	32.3	365	94.3	22	5.7	387
Woodworker, Class D*	154	56.8	91	33.6	245	90.4	26	9.6	271
Woodworker, Class E*	220	64.5	103	30.2	323	94.7	18	5.3	341
Woodworker, Class F*	50	58.8	29	34.1	79	92.9	6	7.1	85
Woodworker, Class G*	3	20.0	10	66.7	13	86.7	2	13.3	15
Woodworker, Class H*	107	78.1	28	20.4	135	98.5	2	1.5	137
Woolen Mills	1349	70.4	483	25.2	1832	95.6	84	4.4	1916
Wool Scouring Plants	44	68.7	17	26.6	61	95.3	3	4.7	64
Wool Storehouses	35	68.6	13	25.5	48	94.1	3	5.9	51
Worsted Mills	114	61.6	56	30.3	170	91.9	15	8.1	185
Total	43025		15985		59010		2398		61408

*The Woodworkers are classified as follows:

Class A. Interior Woodwork, builders' supplies (including veneer works). Class B. Box Factories (including cigar boxes). Class C. Miscellaneous Woodworkers. Steam power tenant Woodworkers. Woodworkers where there is a lack of detailed information as to class. Class D. Sash, Door and Blind Factories. Class E. Hard Wood Turning (wheels, pipes, novelties, bobbins, spools, etc.). Class F. Pails and Woodenware (plates, wooden bowls, tubs, etc.). Class G. Wood Flour Mills. Class H. Wood Heel and Shoe Last Factories.

†Other Metal Working Occupancies are included under Agricultural Implements; Automobile and Bicycle Factories; Bolt, Nut and Screw Works; Electrical Appliances; Forge and Smithy; Foundries; Machine Works; Rolling, Wire and Tube Works; and Stamping and Sheet Metal Works.

**See detailed classification of Tanneries as given in note under Table No. 5.

Table No. 5 — Classification of Unsatisfactory Sprinkler Fires by Occupancy.

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of high test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Plugged heads and clogged piping.	Miscellaneous.	Total.
Abrasive Works	..	1	..	..	..	..	..	..	..	..	..	..	1	2
Agricultural Implements	3	1	..	..	..	..	..	1	1	..	..	..	..	6
Alcohol Distilleries	..	..	..	..	..	..	..	..	..	1	..	..	..	1
Aluminum Works	..	..	..	..	..	..	..	..	1	1	..	..	..	2
Amusement Places	3	..	..	..	..	..	1	..	..	..	..	1	..	5
Artificial Leather Mfg.	..	..	..	..	..	..	1	..	..	2	..	..	..	3
Asbestos Works	..	..	2	..	..	..	..	..	..	1	..	..	..	3
Automobile Mfg.	11	2	2	..	1	..	..	4	..	2	1	2	..	25
Auto Body Mfg.	4	6	3	..	2	..	1	3	1	1	3	1	1	26
Auto Sales and Service	3	1	..	1	..	..	..	..	..	1	..	..	..	6
Bag Factories	1	..	..	..	..	2	..	1	..	..	..	2	..	6
Bakeries	4	1	..	..	..	..	1	..	..	..	..	..	2	8
Basket Factories	..	..	..	..	..	..	..	..	..	..	1	..	..	1
Battery Mfg.	2	..	..	..	..	..	..	..	..	..	..	1	..	3
Bolt, Nut, and Screw Works	1	2	..	..	..	..	..	..	..	..	..	..	..	3
Bottling Works	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Braid Mills	..	1	..	..	..	..	..	1	..	..	..	..	..	2
Brass and Copper Works	1	1	..	..	..	..	..	..	..	..	..	..	1	3
Broom Factories	3	..	..	..	..	..	..	..	..	..	..	..	..	3
Brush Factories	..	..	..	1	..	..	..	..	..	..	..	..	..	1
Building Construction	1	..	..	..	..	..	1	..	..	..	..	..	..	2
Button Factories	..	..	..	2	..	..	..	..	..	..	..	..	..	2
Candy Factories	4	..	..	1	1	..	1	..	..	..	1	2	1	11
Canneries	1	..	..	..	1	..	..	..	..	..	1	..	..	3
Car Houses	2	3	1	..	1	..	..	1	..	..	..	1	..	9
Car Works	2	..	..	..	..	..	1	1	..	..	..	..	..	4
Carpet and Rug Mills	4	3	4	1	..	..	..	2	..	..	..	..	..	14
Casket Mfg.	2	..	..	1	1	..	1	..	..	..	..	..	..	5
Cement and Plaster Mills	1	1	..	..	1	..	..	..	..	..	..	..	..	3
Cereal Mills	..	2	1	..	..	..	..	1	..	4	..	..	..	8
Chemical & White Lead Wks.	3	5	..	..	..	..	..	1	6	9	1	..	1	26
Clothing Mfg.	10	2	1	1	..	..	3	2	..	..	2	2	2	25
Clubs—City	..	..	..	..	..	..	1	..	..	..	..	..	..	1
Clubs—Country	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Coal and Wood Yards	..	..	1	..	..	..	..	..	..	..	..	..	..	1
Coffee and Spice Plants	2	..	..	..	..	..	..	..	..	1	..	..	..	3
Cooperage Plants	1	4	..	..	..	1	2	4	..	..	2	..	..	14
Cordage Works	5	5	1	1	..	..	..	3	..	..	..	..	1	16
Cork Plants	1	..	1	..	..	..	..	..	2	1	..	..	1	6
Cotton Gins	1	1	..	..	..	..	..	..	..	..	..	..	..	2
Cotton Mills	43	28	11	2	2	1	5	3	4	1	..	7	15	122
Cotton Seed Oil Mills	4	7	4	..	..	..	..	..	2	..	..	1	2	20
Cotton Warehouses	17	4	9	..	2	..	1	8	3	..	..	4	3	51
Cutlery Mfg.	1	1	1	..	..	..	..	..	..	..	..	..	..	3
Department Stores	12	4	1	..	2	..	2	1	..	..	2	..	1	25
Distilleries	2	..	..	..	..	..	..	..	..	1	1	..	1	5
Drug Mfg. and Warehouses.	3	..	..	..	1	..	..	..	..	1	3	..	1	9

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of high test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Plugged heads and clogged piping.	Miscellaneous.	Total.
Dry Cleaning Establishments	..	..	..	..	..	..	..	..	1	..	..	1	..	2
Dry Goods Stores	4	..	..	..	..	..	1	1	..	..	..	..	..	6
Dwellings	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Dyeing, Bleaching, Finishing	7	3	1	..	1	2	..	2	..	..	1	1	1	19
Electrical Appliance Mfg.	3	1	2	..	..	..	1	2	..	1	..	1	3	14
Electric Power and Light	2	1	..	..	..	..	..	1	..	..	..	..	..	4
Excelsior Factories	..	..	3	..	1	..	..	..	1	..	..	..	..	5
Fertilizer Plants	2	1	..	..	1	..	..	..	..	..	..	..	..	4
Fibre Products	1	1	1	..	..	..	..	1	..	..	..	1	..	5
Fireworks Plants	..	..	..	..	..	..	..	..	..	2	..	..	..	2
Flax and Linen Mills	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Flour and Grist Mills	10	5	2	..	1	..	1	1	2	6	2	..	2	32
Forge and Smithy	..	..	..	..	..	..	..	1	..	..	..	..	1	2
Foundries	15	..	1	..	1	..	1	1	..	2	1	..	..	22
Fur Works	2	1	..	..	..	..	2	..	..	..	..	..	1	6
Furniture Factories	42	23	10	4	2	..	4	12	15	1	4	4	2	123
Furniture Stores	6	..	..	..	1	..	1	..	..	..	..	..	..	8
Garages	13	..	..	2	1	..	..	3	..	1	..	..	1	21
Garbage Reduction Plants	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Gas Works	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Glass Factories	4	4	3	1	..	..	3	1	..	..	..	..	3	19
Glove Factories	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Glue Factories	2	..	..	..	..	..	..	..	1	..	..	..	..	3
Grain Elevators	1	5	5	..	4	..	2	1	1	5	2	..	1	27
Groceries	7	..	1	..	1	..	1	..	1	1	..	..	..	12
Hardware Stores	2	..	..	..	..	..	..	..	..	..	..	..	1	3
Hat Factories	9	4	2	..	1	..	..	2	..	..	..	..	3	21
Hotels—Year Round	2	1	1	..	..	..	1	..	..	..	..	..	..	5
Hotels—Seasonal	..	..	..	..	..	..	1	..	..	..	..	..	..	1
Ice Houses	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Idle and Vacant Property	16	1	..	3	..	..	1	1	..	..	1	1	..	24
Insulated Wire Works	..	2	..	..	..	..	..	..	..	..	..	..	..	2
Jewelry Factories	4	1	..	2	..	..	1	..	..	..	..	..	..	8
Junk Shops	3	..	..	..	1	..	..	..	..	..	1	..	..	5
Knitting Mills—Cop Yarn	1	1	3	..	..	..	..	1	..	1	..	..	..	7
Knitting Mills—Full Process	12	10	6	1	1	..	1	..	..	1	..	1	..	33
Lamp Shade Factories	..	..	1	..	..	..	..	..	..	..	..	..	..	1
Laundries	7	..	1	..	..	..	..	1	..	..	..	..	..	9
Leather Working	1	..	1	..	1	..	..	1	..	..	..	..	1	5
Linoleum Works	..	8	1	..	..	..	2	2	7	..	..	..	..	20
Linseed Oil Works	2	1	..	..	..	..	1	..	1	2	..	2	..	9
Lumber Yards	..	..	..	..	..	..	..	..	..	..	1	..	..	1
Macaroni Factories	2	..	..	.	..	..	..	..	..	..	..	..	..	2
Machine Shops and Works	19	6	1	1	..	1	..	..	1	2	..	2	..	33
Match Factories	2	..	..	..	..	..	..	..	2	..	..	..	1	5
Mattress Factories	13	2	..	1	..	..	..	2	..	..	..	..	..	18
Mercantile (Miscellaneous)	15	6	1	2	..	..	5	..	..	..	4	..	2	35
Metal Workers†	27	18	4	1	2	2	5	4	6	5	2	3	3	82

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of high test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Plugged heads and clogged piping.	Miscellaneous.	Total.
Mining Property	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Mirror Mfg.	..	..	..	..	..	..	1	..	..	..	..	..	..	1
Miscellaneous	5	2	1	..	2	..	2	..	5	..	..	..	2	19
Motion Picture Exchanges	..	..	..	..	1	..	..	..	1	..	..	..	..	2
Motion Picture Studios	..	..	..	..	..	..	..	..	..	1	..	..	..	1
Motion Picture Theatres	2	1	..	..	..	..	..	1	..	1	1	..	..	6
Multiple Occupancy	4	1	1	1	1	..	6	..	..	2	..	..	1	17
Munition Plants	2	..	..	1	..	..	..	..	4	2	..	..	1	10
Musical Instrument Mfg.	1	4	..	..	..	..	1	..	..	..	1	..	..	7
Office Buildings	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Oil Cloth Works	..	..	..	..	..	..	..	1	6	..	..	..	..	7
Oil Clothing Factories	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Oil Refining—Animal	..	..	1	..	..	..	..	..	..	..	..	..	..	1
Oil Refining—Mineral	..	..	..	..	..	1	..	..	..	..	..	..	..	1
Oil Refining—Vegetable	1	..	1	..	..	..	..	..	..	..	..	..	..	2
Packing Houses	7	2	1	..	2	..	..	..	1	1	..	..	1	15
Paint and Varnish Works	4	3	6	..	1	..	3	1	..	3	..	..	..	21
Paper Coating Mills	2	..	..	..	..	..	..	2	..	1	..	..	1	6
Paper Mills	33	26	19	5	2	3	3	10	4	3	3	8	11	130
Paper Working	7	1	..	..	1	..	..	3	1	..	..	1	..	14
Peanut Roasting Plants	..	..	1	..	..	..	..	..	..	..	2	..	..	3
Pencil Factories	..	..	..	..	..	..	..	..	..	1	..	..	..	1
Phonograph Works	2	..	..	..	..	..	..	..	..	..	..	..	..	2
Photo Engraving & Studios	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Picture Frame Mfg.	1	2	1	1	..	..	..	1	..	..	..	..	..	6
Piers and Wharves	..	2	1	..	..	..	..	..	..	..	..	..	..	3
Plumbers Supplies	2	1	..	..	..	..	..	..	..	..	..	..	..	3
Potteries	3	2	1	1	..	..	..	..	..	1	..	..	..	8
Printing and Lithographing	12	5	1	..	1	..	3	1	1	..	3	..	1	28
Prisons	..	..	..	..	1	..	..	..	1	..	..	..	..	2
Public Buildings	..	..	..	..	1	..	..	..	..	..	..	1	..	2
Pulp Mills	12	4	4	..	1	1	1	..	1	1	..	..	2	27
Pyroxylin Plastic Mfg. and Fabricating	4	1	3	1	1	..	2	2	23	6	2	..	..	45
Radios and Accessories	2	..	..	..	..	..	..	..	..	..	..	1	..	3
Railroad, Miscellaneous	..	..	..	..	..	..	..	..	..	..	..	1	..	1
Rayon Mills	..	1	..	..	..	..	..	..	..	..	..	..	1	2
Restaurants	1	1	..	..	..	..	1	..	..	..	..	..	..	3
Rice Mills	..	1	1	..	..	..	..	..	..	..	..	..	2	4
Rolling Wire and Tube Mills	..	1	..	..	1	1	1	..	..	..	1	1	..	6
Roofing Works	3	2	1	1	..	..	1	2	..	1	..	..	..	11
Rooming & Lodging Houses	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Rubber Cloth Factories	2	1	..	..	..	..	..	..	..	..	..	..	1	4
Rubber Reclaiming Works	3	..	1	..	..	..	1	1	2	1	1	..	..	10
Rubber Mills	9	1	..	1	..	..	..	1	7	7	..	1	1	28
Saw and Planing Mills	22	15	7	1	7	1	6	4	9	..	5	1	5	83
Schools—Private	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Schools—Public	1	1	..	..	..	..	1	..	..	..	..	..	..	3
Schools—Trade & Industrial	1	..	1	..	..	..	..	..	..	..	..	..	..	2

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of high test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Plugged heads and clogged piping.	Miscellaneous.	Total.
Shipyards	2	1	..	..	..	..	..	..	..	..	..	..	..	3
Shoddy Mills	6	4	7	1	1	3	1	2	..	..	..	..	1	26
Shoe Factories	20	8	3	..	1	1	2	3	..	3	6	1	3	51
Shoe Mfg. Accessories	3	2	..	1	..	..	..	..	..	..	..	..	1	7
Silk Mills	3	2	..	..	..	..	..	..	..	1	..	..	2	8
Smelting and Refining	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Soap Manufacturing	2	1	..	..	..	..	..	..	..	..	..	..	..	3
Stamping & Sheet Metal Wks.	4	5	1	..	1	..	2	1	..	1	2	..	1	18
Starch and Glucose Works	..	..	..	..	..	..	..	..	1	7	..	..	..	8
Sugar Refineries	2	1	..	..	..	..	..	..	..	1	..	..	..	4
Tannery, Class A**	1	1	..	1	..	..	..	..	..	..	1	..	1	5
Tannery, Class B**	9	4	..	2	3	..	1	1	..	..	..	..	1	21
Tannery, Class C**	2	..	1	1	..	..	1	..	..	..	1	..	..	6
Tannery, Class D**	..	..	..	2	..	..	..	..	..	..	..	..	..	2
Tenant Mfg.	60	11	2	5	1	..	4	4	2	1	7	2	3	102
Theatres	5	3	..	..	..	..	..	..	..	..	..	..	..	8
Tobacco Factories	1	1	..	..	..	..	..	..	1	..	1	..	..	4
Tobacco Warehouses	..	.	..	..	..	..	.	..	..	..	1	..	..	1
Trunk Factories	3	1	1	..	..	..	1	..	..	..	1	..	..	7
Umbrella Mfg.	..	..	..	..	..	..	..	..	..	1	..	..	..	1
Wall Paper Factories	..	..	1	..	..	..	..	1	1	..	1	..	..	4
Warehouses	14	4	5	..	2	..	3	3	2	1	..	2	3	39
Waste and Batting Mills	10	4	5	2	2	1	..	2	2	..	..	3	1	32
Waste Paper and Rag Sorting	13	4	1	3	..	..	..	1	..	..	..	..	2	24
Weaving Mills	1	1	2	1	..	..	..	2	..	..	..	..	..	7
Window Shade Factories	..	..	..	1	..	..	..	..	1	..	..	..	..	2
Woodworker, Class A*	14	12	5	1	2	1	2	6	1	3	4	2	4	57
Woodworker, Class B*	10	9	3	3	1	2	1	1	..	3	2	3	..	38
Woodworker, Class C*	7	6	3	..	..	..	1	3	..	1	..	..	1	22
Woodworker, Class D*	3	12	..	1	1	..	..	..	..	2	4	..	3	26
Woodworker, Class E*	7	1	1	..	2	1	2	..	1	..	1	1	1	18
Woodworker, Class F*	2	1	1	..	..	..	..	2	..	..	..	..	..	6
Woodworker, Class G*	..	..	..	..	..	..	..	..	..	2	..	..	..	2
Woodworker, Class H*	..	1	..	..	..	..	..	..	..	..	..	1	..	2
Woolen Mills	23	21	17	2	..	2	4	1	1	..	3	4	6	84
Wool Scouring	..	1	1	..	..	..	1	..	..	..	..	..	..	3
Wool Storehouses	1	2	..	..	..	..	..	..	..	..	..	..	..	3
Worsted Mills	3	4	2	1	..	..	1	..	..	..	..	..	4	15
Total	803	406	209	70	75	27	117	141	138	116	91	75	130	2398

†See note on Metal Workers under Table No. 4.
*See detailed classification of Woodworkers as given in note under Table 4.
**The Tanneries are classified as follows:
Class A. Sole Leather and Belting.
Class B. Upper Leather (Calfskins, Sheepskins, Morocco).
Class C. Patent Leather.
Class D. Skin Mills (Glove Leather).

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